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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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Forthcoming Events.

JANUARY 25.

West of Scotland Iron and Steel Institute:—Ordinary meeting at Glasgow. "The Manufacture of Iron and Steel Tubes," Paper by J. Mitchell.

Institution of Production Engineers:—General meeting at 83, Pall Mall, London, S.W.1. L. H. Pomeroy, F.R.S.A., will lecture on "The Designer *v.* the Production Engineer."

JANUARY 29.

Sheffield Metallurgical Association:—Ordinary meeting. "The Influence of Surface Conditions and Internal Stresses on the Physical Properties of Cold-worked and Quenched and Tempered Steels, with particular reference to Fatigue Resistance," Paper by Prof. F. C. Lea, D.Sc.

Institute of British Foundrymen.

FEBRUARY 1.

Middlesbrough Branch:—Ordinary meeting at Cleveland Technical Institute. "Progress and Precision in Motor Cylinder Manufacture," Paper by W. West.

FEBRUARY 2.

Lancashire Branch:—Joint meeting with the West Riding of Yorkshire Branch.

Low Total Carbon Content.

Some fifty years ago the examination at Woolwich of 850 specimens of cast iron sent in for competition produced tensile strengths ranging from the lowest at a little over 4 tons per sq. in. to the highest at a little over 15 tons per sq. in. The average result of all the tensile strengths in this examination was 21,173 lbs., or a little under 10 tons per sq. in. If a similar competition were organised to-day there can be little doubt but that the metallurgical progress in cast iron made would be reflected in the much higher average figure which would undoubtedly be obtained. It might be within the scope of the activities of our British Cast Iron Research Association to organise a similar competition with the very laudable object of confirming quantitatively the progress made in the interval.

To-day there is a more comprehensive understanding of the chemistry of cast iron, and the total-carbon content would be one of the first of the important factors to be seized upon in explaining this progress. The difference between steel, with its high strength and ductility, and cast iron, with its low strength and absence of ductility, is principally one of total-carbon content. The logic underlying the reasoning that a reduction in total-carbon contents will have the effect of bringing the composition of cast iron nearer to that of steel, and can be expected to be accompanied by improved mechanical properties, has appealed to all searchers after high-strength cast iron. This is the reason for the vastly extended interest in irons of low total-carbon content during recent years, and such irons have now had extended practical use in many foundries. The time has now arrived when we may expect to learn the true practical value and behaviour of the reduction in total-carbon content.

Whilst our metallurgists have never expected that any improvements in the mechanical properties of cast iron would occur in strict proportionality with the reduction in total-carbon contents, the recent pronouncements of two most important foundrymen will come somewhat as a surprise. Recently, in discussing high-duty cast iron, Mr. John Shaw warned us that even in air-furnace practice the reduction in total-carbon contents is accompanied by "other troubles." These have been sufficiently important, we are told, to induce the Gunnell people to raise their recommended value of total-carbon content to 3 per cent.—a value which is to be regarded presumably as a minimum. We were also told quite recently by Mr. H. J. Young that low total-carbon irons have not done so well as people expected. From the evidence submitted by this latter authority it would be anticipated that the shortcomings of low total-carbon content are to be ascribed, at any rate partially, to the variations in amount of this constituent. Neither of these two sources provides us with extended information as to the troubles arising out of low total-carbon content material, and exactly in what respect they fail to come up to expectation. We are entitled to suspect that the troubles are not unconnected with the higher melting points, the longer freezing range—and the increase in amount of total shrinkage—associated with the reduction in total-carbon content.

In the lower values of total-carbon content we may suspect inconstancy in cupola-melted iron, and this would naturally be accompanied by irregular mechanical test-figures. It is by no means yet clearly established that high mechanical test-figures are associated invariably with low total-carbon content, or that these progressively increase with a decrease in the amount of this constituent. We may suspect strongly something in the nature of a critical percentage of total-carbon content beyond which lower values are either unaccompanied by increased strength or any increase in strength is by no means commensurate with the other difficulties encountered. This critical value of low total-carbon content may be about 3 per cent.

Rationalisation Again.

We have frequently referred in these columns to the movement described as rationalisation in industry, and more especially to those Continental manifestations of it that have taken the form of large-scale industrial reorganisations and combinations. During the last few weeks there have occurred two instances that touch the English industrialist more closely, and that have been given considerable publicity. The first is the big nickel merger, as a result of which some 80 per cent. of the world's nickel output will be controlled by the same hands. The second is the Vickers-Armstrong and Camell-Laird grouping, in itself only the latest of a number of reorganising efforts in the heavy industries in this country.

The adherence of such important interests to the rationalisation principle should not be without its lesson to the founding industry. While it is essential to remember that every industry has its own problems requiring their own special solution, rationalising methods can be applied with advantage in every case. What is more, they are bound to be adopted as time goes on, whether deliberately or accidentally.

It is therefore not only interesting but important to consider what these methods would be in relation to the foundry industry. The tremendous industrial unit is not for us, for foundry work is basic in its relation to every kind of industry, so that it has to be spread widely over the country, and for the most part in small units. Where rationalisation would step in, however, would be in the direction of specialisation, and at the moment

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a serious attempt is being made in the light castings industry, where a huge merger is being discussed. The total output would not be affected, unless it were in the direction of an increase, but it would be redistributed, so that the concentration of one type of work in one place would be facilitated. This would probably result in highly specialised foundries, each producing a single type of work, but producing it in large quantities and with a high degree of efficiency and economy. In any wise application of rationalising methods, this specialisation would be dictated primarily by the proved ability of a given foundry to produce a given type of work superlatively well.

Such reorganisations are not and cannot be undertaken hastily. Their success must depend upon due regard being taken for questions of equipment, staff, and technical control, these matters within the industrial unit being within the scope of rationalisation no less than the bolder ones of large-scale redistribution.

Rationalisation means, in effect, the application of rational methods to our industrial problems in place of the haphazard fashion in which we have so often treated them in the past. Some such development as we have outlined above would appear to be the rational future development of founding.

Foundry's Increased Export Trade.

The foundry of Qualcast, Limited, Derby, reports a good year of export trade. The last half year of 1928, compared with that of 1927, shows an increased turnover on home trade of 13 per cent., and on export trade of 23 per cent., giving the total turnover an increase of 16 per cent. The net profit is estimated to have increased by 22.4 per cent.

The new foundry building is nearing completion and the company anticipates being in possession of it during May of this year. From thence the company will commence to take advantage of the earning capacity of the new capital, which, at present, is invested in War Loan.

The firm has striven to promote the best feeling among its employees, and, although a wage-reduction was recently agreed upon by the Trades Unions, the directors did not enforce this, because they felt that the company's progress originated from the whole-hearted co-operation. They reserve, however, the right to apply this reduction if necessary at some future date, but during a period of prosperity they do not consider that the action would be justified.

Symposium on Apprentice Training.

On January 17 the Junior Section of the Scottish Branch, I.B.F., held a symposium on apprentice training from the apprentice's point of view. Papers were read by Stuart White, who dealt with the iron moulders' case; John Darby took the views of the non-ferrous moulders' idea of training, and Chas. P. Singer the training of apprentice patternmakers. Mr. J. Longden, President of the Scottish Branch, presided. There was an animated discussion in which many of the members and certain welfare supervisors took part.

WEDDING GIFTS were presented by the electricity department staff of the Glasgow Iron and Steel Company, Limited, Wishaw, to Mr. William MacFarlane on his approaching marriage.

MR. A. MURDOCH, a director of the Singer Manufacturing Company, Limited, Clydebank, at the first annual dinner of the Singer Social Club, held in Glasgow, stated that the past year had been one of the steadiest in the Singer Company's history, and he was glad to be able to say that there was every reason to anticipate that the present year's trade would be even more prosperous.

I.B.F. Branch Presidents.

No. 1—SCOTTISH SECTION.

At the age of 13 Mr. John Longden entered the foundry of Messrs. A. Dunn & Sons, Manchester, as apprentice moulder. Before completion of his apprenticeship he went into the service of Messrs. Royles, Limited, Irlam (near Manchester), where the foundry manager gave him the status of journeyman at the age of 20. Leaving this firm eight years later, he entered the service of the British Westinghouse Electric and Manufacturing Company (now the Metropolitan-Vickers concern), Manchester, as moulder, where, after a short period, he was appointed assistant foreman, and then foreman, having full charge of their No. 2 foundry. Early in 1919 he left to take up an appointment on the headquarters staff of the Ministry of Labour, Whitehall, as negotiating officer, in connection with the declared policy of the Government to promote the formation of Joint Industrial (Whitley) Councils. Following the famous "Limpet" campaign of the "Daily Mail," he left the service of the Ministry towards the end of 1921, and entered the service of the Lennox Foundry Company as foreman in their Tantiron foundry. In the following year he took up his present post of foundry manager to Messrs. D. & J. Tullis, Limited, Clydebank, the eminent firm of laundry machinery and machine tool makers.

MR. JOHN LONGDEN
(President of the Scottish Branch of the Institute of British Foundrymen).

His early education was that of the elementary school, followed by evening continuation school, which was succeeded by part-time study at the Manchester School (now College) of Technology, the Manchester High School of Commerce, and Manchester University Tutorial Classes. In 1919 he was Hodgson Pratt Scholar at Ruskin College, Oxford, and later gained the Oxford University Diploma in economics and political science, with distinction. He took some interest in local government, and was for seven years a member of Irlam Urban District Council. He has also done some lecturing for the Workers' Educational Association.

He joined the Institute of British Foundrymen in 1921, and acted as assistant to the then Secretary of the London Branch, Mr. V. C. Faulkner. He became a member of the Council of the Scottish Branch in 1924. He has read a number of Papers before various Branches of the Institute, and in 1926 was awarded the Diploma of the Institute for his Paper on "Liquid Shrinkage in Grey Iron."

Random Shots.

The imminence of a General Election—I have heard rumours concerning the date of polling day—tempts to speculation on the influence of extraneous events on trade. Trades that are subject to vagaries of weather or of fashion are, of course, the most striking examples. We have all heard of the distress caused among hairpin kings in America by the spread of the shingle; or of the part played by modern abbreviated garments in the troubles of the cotton trade. We have all wondered what the bathing-machine man does in the winter, and suffered from the desire of the seaside landlady to make a year's livelihood in six weeks.

* * *

But there are other and wider influences that are felt, not merely within a given trade, but throughout the whole of industry. Such has been the effect of the King's illness. During the anxious weeks before Christmas the whole country undoubtedly suffered more or less from the retarding effect of the uncertainty and apprehension that existed on this ground. It was felt most vividly in the capital, where I have even heard it said that the activity of Christmas shoppers varied not merely from day to day but from hour to hour as the bulletins were published. Theatres, restaurants, etc., also suffered. And, spreading outwards from this small patch of acute influence, went the hesitation, the uncertainty, the holding back of orders and decisions.

* * *

In a different way a General Election cannot fail to influence trade. Will it arouse much or little enthusiasm throughout the country? What will be the result? Will there be any violent changes of policy? If so, how will they affect us. These and similar questions can hardly fail to be at the back of everyone's mind as the spring approaches.

* * *

Talking of changes, a goodly number will no doubt be induced if and when the Channel tunnel scheme comes to fruition. There is something just a shade romantic about the whole thing that causes everyone to stop and ponder it, if only for a moment. To some it means easier trade with the Continent, and to others more comfortable travel. But to my mind the great significance of the present "boost" lies in this, that it proves that at long last we really have put the war behind us. No such scheme could have been seriously propounded until the war spirit was very solidly and safely buried. And that, I feel, is very much to the good.

* * *

A financier lay dying, and his sorrowing partner sat sadly at the bedside. "Isaac," gasped the sick man, "I have a confession to make to you. Some years I ago I robbed the firm of £10,000, while I also sold some of our greatest secrets to a rival for a similar sum. I also provided the evidence that caused you to be cited in that divorce case. Can you ever forgive me?" "That's quite all right, old man, don't worry!" came the soothing reply. "It was me who poisoned you, so we're quits!"

* * *

And here is the latest Aimée Macpherson story. The evangelist called on the congregation at the end of a lively peroration and asked if anyone was saved. An old man bowed his head. "There," said Aimée, "There is one sinner who has repented!" At that moment the man raised his flushed features. "Where the devil is my hat?" he asked his next-door neighbour.

* * *

Another good one, told by Mr. Walter Jerrold, is this: A Chicago patriot, having died, found himself in the next world, and, looking round him, said: "Heaven isn't so very much better than Chicago after all." "S-sh" came a voice, "this isn't heaven."

MABKSMAN.

Investigations into Moulding Sands.

In the first part of a comprehensive investigation H. Nipper and E. Piwowarsky* studied the permeability of moulding sands. The permeability was examined by measuring the pressure being necessary for driving a definite quantity of gas through a sand test-piece in unit of time. The apparatus used in these experiments is illustrated in Fig. 1, wherein *a* is the casing of the apparatus into which a cylinder of sheet steel, *b*, is set to support the test-piece; by the manometer, *c*, the pressure existing at the front and back of the test-piece is measured; *d* means a rotameter for measuring the quantity of gas. The gas used

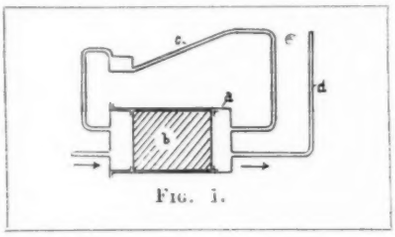

FIG. 1.

was carbon dioxide; the quantity was 175 litres per hour. The round test-pieces were 2.365 in. high and had a diameter of 2.205 in. To insure an equal compression, all the test-pieces were jolted with the same number of blows and the same height of stroke. The raw materials were ground and sieved quartzite (sharp grains, grains size from 0.04 to 0.8 millimetres), sieved river sand (round grains, grains size from 0.06 to 0.8 millimetres), and a moulding clay. With the aid of a formula given by Schwolson the authors calculate that under the present conditions the permeability is indirectly proportional to the difference of the pressures existing at the front and back of the test-piece.

In the preliminary experiments the following facts were enunciated:—(1) The quantity of gas passing through the test-piece is proportional to the pressure difference irrespective of the number of blows and the height of stroke. (2) The temperature of the carbon dioxide has no influence on the quantity of gas passing through the test-piece; in spite of this fact the temperature of the carbon dioxide was kept constant in the further experiments. (3) The best method of mixing insuring a uniform distribution of the bond was found to be the following:—Sand and clay were mixed in the dry state for two minutes, the definite quantity of water was added, and mixing was continued for five to ten minutes. (4) The difference of pressure ceased to change for all the grain sizes investigated when the number of blows was 50 and the height of stroke 1.26 in. The experiments also showed that it was more difficult to compress the sharp sand than the round sand. (5) The difference of pressure is directly proportional to the length of the test samples. From that it is to be seen that the compression of sand moulds brought about by the jolting machine is a very uniform one. (6) The length of time during which the gas passes the test sample has no influence upon the permeabilty. (7) The quantity of the water added for mixing has no influence upon the distribution of the bond. (8) With the increasing temperature of the added water the permeability decreases. This may be due to the fact that hot water causes a swelling of the bond. In the following experiments the added water had a standard low temperature.

In the further investigation, experiments were made with seven grain sizes of the round sand and the sharp sand. In each series the content of the bond changed from 0 to 30 per cent., and the water content from the lowest possible content to 20 per cent.

The results of the experiments are recorded in many tables; one of these is reproduced below (Table I), showing the highest permeability attainable with a definite grain size containing varying amounts of bond and water. From the data it is seen that the permeability increases with the increasing bond content, and that with a definite bond-content there exists an optimum of the water content. That may be due to the fact that the bond causes an enlargement of the sand grains, increasing with the increasing bond-content. On the other hand, it may be possible that the compression energy, which was equal for all the grain sizes investigated, has not the same effect with the increasing bond-content.

TABLE I.

Grain size.		Bond content.	Round Grains. Water content.	Round Grains. Pressure difference. Water gauge.	Sharp Grains. Water content.	Sharp Grains. Pressure difference. Water gauge.
mm.		Per cent.	Per cent.	mm.	Per cent.	mm.
0.8		0	3.29	0.36	2.88	0.24
0.8		4	1.93	0.28	2.74	0.23
0.8		8	1.80	0.27	2.86	0.21
0.8		12	4.19	0.20	3.48	0.18
0.8		16	5.13	0.21	6.59	0.19
0.8		20	5.66	0.17	7.09	0.14
0.8		25	6.53	0.11	7.67	0.18
0.8		30	7.52	0.20	7.99	0.16
0.6		0	2.15	0.60	2.47	0.48
0.6		4	1.05	0.44	1.87	0.47
0.6		8	1.81	0.35	3.11	0.42
0.6		12	3.79	0.44	3.42	0.35
0.6		16	4.90	0.47	3.76	0.36
0.6		20	5.79	0.30	6.57	0.43
0.6		25	5.92	0.16	8.30	0.28
0.6		30	7.90	0.18	8.91	0.21
0.4		0	1.18	0.93	3.14	0.60
0.4		4	1.31	1.05	3.09	0.60
0.4		8	1.80	0.93	3.64	0.36
0.4		12	3.98	0.64	4.12	0.52
0.4		16	4.97	0.45	4.88	0.41
0.4		20	5.26	0.40	7.50	0.51
0.4		25	5.48	0.30	7.55	0.40
0.4		30	7.30	0.15	7.34	0.40
0.25		0	1.99	2.30	2.77	1.60
0.25		4	2.27	2.40	2.55	2.20
0.25		8	2.28	1.70	3.07	2.10
0.25		12	5.47	1.40	6.56	1.70
0.25		16	5.79	1.20	6.62	1.70
0.25		20	6.01	0.90	4.52	1.30
0.25		25	6.25	0.60	7.34	0.90
0.25		30	8.65	0.60	8.90	0.70
R'd.	Sh'p					
0.15	0.16	0	6.57	4.20	7.44	3.50
0.15	0.16	4	2.30	5.30	7.99	3.00
0.15	0.16	8	2.51	5.80	7.00	3.40
0.15	0.16	12	6.29	5.00	8.09	3.00
0.15	0.16	16	6.03	4.40	7.70	2.70
0.15	0.16	20	6.76	3.90	8.81	1.80
0.15	0.16	25	6.83	2.10	7.84	1.90
0.15	0.16	30	8.07	2.40	8.28	1.10
0.1	0.08	0	8.50	6.90	11.49	8.20
0.1	0.08	4	5.76	8.90	6.40	9.90
0.1	0.08	8	9.30	6.90	10.17	9.10
0.1	0.08	12	10.81	5.90	10.52	6.20
0.1	0.08	16	9.24	6.20	13.34	6.60
0.1	0.08	20	9.00	5.50	9.88	5.00
0.1	0.08	25	9.26	3.00	12.63	4.90
0.1	0.08	30	11.56	3.00	10.15	4.00
0.06	0.04	0	12.08	9.50	9.34	7.00
0.06	0.04	4	11.00	9.70	11.50	11.70
0.06	0.04	8	9.66	9.10	13.54	11.00
0.06	0.04	12	9.48	10.40	7.08	15.00
0.06	0.04	16	9.81	6.90	13.08	7.20
0.06	0.04	20	9.39	5.60	13.65	3.70
0.06	0.04	25	12.18	5.40	12.49	4.00
0.06	0.04	30	12.24	3.10	11.22	4.40

From the experimental results the authors draw the following conclusions:—(1) With a definite grain size the permeability increases with the increasing bond-content, the necessary water content increasing at the same time. This increase is the greater the smaller the grain size; furthermore, it is greater with the sharp sand than with the round sand. (2) With a definite grain size containing a definite bond-content the maximum of the permeability is attained at with a definite water content. With the increasing bond-content the maximum is displaced to a higher water content; this tendency is more pronounced with the sharp sand than with the round sand. (3) The influence of a deviation from the most favourable water content upon the permeability increases with the decreasing grain size and the increasing bond-content. This influence is greater with the sharp sand than with the round one, especially with the small grain sizes. (4) The maximum of the permeability shows the highest value with the largest grain size.

TABLE II.

Grain size.	Permeability. With most suitable water content.	Permeability. Dry sample.
mm.	Pressure difference. Water gauge mm.	
Round Sand with 16 per cent. of Bond.		
0.6	0.47	1.6
0.4	0.45	2.4
0.15	4.4	6.6
Sharp Sand with 16 per cent. of Bond.		
0.6	0.36	1.6
0.4	0.41	3.0
0.16	2.70	6.0
0.04	7.2	15.9

TABLE III.

Coal dust.	Water.	Pressure difference.
per cent.	per cent.	mm.
0	7.10	1.7
3	7.29	2.3
9	6.91	2.4
12	7.26	2.8

TABLE IV.

Treatment of the sample.	Water content.	Pressure difference.
	Per cent.	mm.
Untreated sample	6.23	1.7
Faced with graphite ..	6.23	13.5
Faced with graphite and dried	0.0	3.5
Faced with blacking ..	6.23	37.8
Face with blacking and dried	0.0	1.9
Faced with lamp black ..	6.3	1.8
Faced with lamp black and dried	0.0	1.1

Further experiments had to show how the permeability is influenced (*a*) by completely drying the mould; (*b*) by adding coal dust to the sand mixture; and (*c*) by facing the mould with graphite, blacking or lamp black respectively.

The figures given in Table II shows that the wet samples have a far greater permeability than the dried ones. The difference is the greater the smaller the grain size. From Table III it is to be seen that the permeability decreases with the increasing coal-dust content of the mixture.

Table IV shows that the permeability is greatly decreased when the mould is faced with graphite or blacking and not dried; this bad influence decreases by drying. Lamp black has only a little influence upon the permeability. Furthermore, the authors give several tables showing the permeability of mixtures consisting of sharp and round sand, and of several grain sizes. The permeability of some natural moulding sands was also examined.

* Die Giesserei, 1928, No. 44, pp. 1,097/1,108.

THE NEW WING of the County Technical College, Wednesbury, was formally opened by Sir Charles G. Robertson, Vice-Chancellor of the Birmingham University, last Friday. Three new laboratories will provide for the increased number of students, the cost of the extension, with equipment, being £9,000. A 50-ton testing machine has been installed.

The Foreman's Relationship to Industrial Co-operation.*

By L. A. HARTLEY.

Any intelligent method of discharging or suspending employees, like skilfully performed surgical amputations, takes account of the general health of the body and the plan for recuperation. In industry this requires consideration of the entire personnel in relation to production. The methods followed in one factory illustrate the intimate connection of discharges with other problems of plant economy and suspensions.

Six Rules of Good Work.

This large concern has established six definite rules of conduct for all employees, regardless of the nature of their duties. The organisation consists of two large plants employing several thousand men and women, and manufacturing different products of highly competitive nature. These rules of conduct apply equally to the general manager and the ordinary labourer. Furthermore, they have been selected because their observance assures personal success in all phases of individual life as well as assuring success on the job and in the business.

These rules have been tested for a considerable period of time, and a careful check has been made of the effect of their observance on the job and in outside relationships; and there is reason to believe that the aims of this management are being achieved. Men who observe these directions do become more efficient, regardless of the job. They also succeed better in their personal affairs, and, consequently, their home life is happier.

The six rules are as follow:—† (1) "Follow instructions willingly; (2) be clean and orderly; (3) take good care of property and materials; (4) work well from whistle to whistle; (5) work every day you can and tell your foreman when you cannot; and (6) work well with others."

These are called "The Six Laws of Good Work." In this big organisation every employee is expected to know them and continually to study their application. Group and individual instruction is organised with this definite objective. An illustrated booklet with full explanations of the Why's as well as the How's of these requirements is given to every employee.

A Two-Sided Programme.

The two-sidedness of the programme is emphasised. The legends under two appropriate cuts in this booklet are "Notify your foreman if you can't come to work" and—"and your foreman will hold your job for you until you are able to work." The common objective of all is stressed. The legend under another picture reads, "We are all working for the same boss, and that boss is the customer."

Soon after this "six law" programme was inaugurated it became necessary to suspend some of the employees in each department. The suspension was partly due to a great flood which had interfered with sales. While the number laid off was not more than is often released in many seasonal businesses this company made use of this suspension as a means for strengthening the organisation.

It is not always the man who knows best how to use the best materials who is most desired on the job. The good carpenter is one who not only knows how to make the best use of good materials, but who also knows where to make use of the less-finished timber which will serve equally well in places not requiring the better finish.

A printed form was prepared which was in reality a form for recording the observance of the six laws by each individual. At the top of the card was a place for the date and the name, department, and job of an employee. Then followed the laws, and opposite each were two squares in which the employee's foreman was to place yes or no, according to whether the employee did or did not observe the particular law. At the bottom was a place for the signature.

The day the suspension was made the foremen were called into the office in groups of from fifteen to twenty, and the purpose of the form was carefully explained. Then each member of each group was encouraged to ask any questions he desired. Each foreman was given to understand that men would be retained in accordance with the foreman's report of the men's observance of these laws, and that it was the purpose of the company to avoid if possible suspending any man who was reported as having an excellent record on this basis.

Favouritism Made Difficult.

Then came the interesting part of the programme. When the records were arriving foremen were called in to discuss very intimate details of their conclusions. Why was John Smith considered as not "following instructions willingly?" The foreman was asked to cite examples of John Smith's having violated the "first law of good work." What were the circumstances of James Brown's violating the second law? And so on throughout all of the report. Very early in this experience some foremen asked that they be given an opportunity to revise their records. Favouritism was soon eliminated by all in an honest endeavour to institute the application of industrial economy according to these principles. The effect of all this upon production is obvious.

Then came the real test of this programme, for some men had to be laid off whose records were good. The management stated that this was the hardest thing they ever had to do in connection with managing a plant. But the case was settled under the sixth law, which refers to co-operation. It will be remembered that the definition of the standard of good work applied to manager and foreman as well as labourer.

A Double-Action Employment Department.

If working well with others meant anything it meant being as helpful as possible to the other fellow at times when he needed help. The company could not economically use these good men just then, but they could put their employment department to work to get them jobs elsewhere, and this they did.

An employment department was actually made to work both ways. Every man who had observed all six laws reasonably well was either kept on the job or a job was found for him with some other company, and when men were re-employed employees who had been suspended were re-engaged in accordance with their record.

This programme is being duplicated by the Ohio Brass Company, Mansfield, Ohio. This organisation did not announce the same laws. In this case seven laws were set forth as follow:—(1) Does he do good work? (2) Is he dependable? (3) Is he careful? (4) Is he clean and orderly? (5) Is he punctual and industrious? (6) Does he follow instructions willingly? (7) Is he agreeable?

In the case of the Ohio Brass Company seven other questions were asked with a view to stimulating the interest of the foremen in the personal welfare of the men and women in the plant. These latter questions were stressed with the result that every foreman in the plant has become much better acquainted with his men. These additional questions are as follow:—(1) Is he single or married. (2) How many dependents? (3) Does he own his home? (4) Is he buying a home? (5) Has he group insurance? (6) Is he in saving plan? and (7) Has he ever made any suggestions for improvemnts?

Fundamentals of Industrial Economy.

These plants have achieved remarkable savings in production. They have noteworthy records in maintenance of equipment; their conservation of materials is unusual; their "scrap" or unusable product is exceedingly low; the plants are kept clean at little extra expenditure; orderliness is apparent; and accident records are extremely low. In addition to all this there is an unmistakable atmosphere of happiness prevailing throughout the organisations. These rules are the fundamental principles of industrial economy in these nationally known manufacturing institutions. Their intelligent application by and to all employees carries the interest in each other's affairs beyond the plant and does it without paternalism.

* A Paper, under the caption of "Some Things Foremen Should be Thinking About" given before the (American) Fational Founders' Association. The Author is the Director of Education to the Association.

† "You and Your Work," p. 3, Frigidaire Corporation, Dayton, Ohio.

Catalogues Received.

Portable Dryers.—Messrs. Pittevil & Company, of 22-28, Laurence Pountney Lane, London, E.C.4, have prepared a four-page pamphlet, printed in two colours, which describes and illustrates Mr. Lamoureux's well-known portable dryer for use in foundries. It will be remembered that this type is motor-driven and is made in two sizes, the larger delivery 540 cub. ft. of hot air (220 to 230 deg. C.) per min., and the smaller 270. The complete absence of refractory materials is a feature of this plant.

Hollow Forgings for High Pressures.—British engineering and metallurgy and the art of publicity at its best have been combined in the production of a brochure published by Messrs. John Brown & Company, Limited, of Sheffield. It is not merely well illustrated, but beautifully illustrated, whilst the type-setting is a model worthy of emulation by others. The technical data relating to the behaviour of steel at elevated temperatures is reliable and clearly set out. We congratulate those responsible on the production of a really worth-while catalogue—one guaranteed to inspire confidence in the minds of those whose pleasure it is to handle it.

Portable Tools.—The Flexible Shaft Manufacturing Company, of Town Road, Edmonton, London, N.9, have sent us a leaflet dealing with the Simplex portable tool outfit. Actually a 6-in. × 1-in. grinding wheel, with an aluminium guard, is illustrated, though other foundry applications such as scratch brushing, polishing, drilling and fettling are referred to. Electrically driven from wall plugs, by means of ⅓-h.p. motor (capable of 1 h.p. for short periods) the outfit for grinding only weighs about 60 lbs. We have found, from personal experience, that many of the foreign-made portable tools are far too heavy to be comfortable for continuous use.

Gas Welding.—We always regard welding from two aspects, (1) as an adjunct to foundry practice, and (2) as representing a competitive process. Thus, on receipt of "Gas Welding, and Its Applications" (Booklet No. 4), price 1s., from the British Oxygen Company, Limited, of Angel Road, Edmonton, London, N.18, we felt that this would not be particularly well received by our readers, as it stresses very forcibly the advantages of welded work over castings. Foundrymen are quite cognizant of this, but do not like it rubbing in too strongly. We thus throw out the suggestion, that there is still such an enormous amount of "repair" welding carried out in foundries as to warrant the preparation of a catalogue devoted purely to their interests. If any founder has not investigated the potentialities of gas welding as either an aid or a competitor, he could not do better than study this 36-page, well-illustrated pamphlet on the subject. It portrays very adequately the existing state of the art (or should it be called a science?).

Grey Iron Castings.—Not all founders think to send to their representative trade organ copies of their catalogues, so the majority which we handle refer to foundry supplies. Thus it is a pleasure to review the type which has been sent to us by Messrs. John Harper and Company, Limited, of Albion Works, Walsall Road, Willenhall, Staffs. Its 56 well-illustrated pages cannot fail to impress any reader that the issuing firm has behind it an organisation capable of co-operating on a scientific and erudite basis for the promotion of their mutual interests. The method adopted and to be commended is to devote the left-hand page to the succinct account of some activity or a phase of foundry practice, and the right to the conveying of impressions of the plant available, and the productions achieved. We have just one adverse comment to make, and that is on pages 11 and 15 of this catalogue (A28) there are illustrated two of their foundry departments, and in these views the men's clothing is to be seen hanging on the shop-walls. We are cognizant of the difficulty in suppressing this bad habit, but that is no reason for allowing overseas buyers to know of its existence.

Automatic Blast-Gate Control for Cupolas.*

By H. V. Crawford.

The foundrymen of to-day are face to face with a new era, and it is exceedingly important that they exert themselves to the utmost in improving every operation in the foundry. More efficient operation is the slogan in all industries, and there is no question but what the melting operation in foundries can be improved to a considerable extent. Scientific operation of the cupola is bound to result in better and more consistent results. In many cases, the object of the foundryman has been to ensure an adequate supply of air, and in order to make certain of this, he arranges to have some excess for any condition, even if it means a very appreciable excess under some other condition. It will be shown that this is not a proper procedure, however, because an excess of air is worse than a deficiency, since the iron, in addition to being cooled, may be burnt.

The operation of the cupola is chiefly a combustion proposition, and the chemists have given us very simple laws covering the union of the carbon in the coke and the oxygen of the air. To obtain the highest efficiency in the operation of the cupola, it is, of course, necessary to utilise the maximum heat units available from the burning coke. The union of the oxygen of the air and the carbon of the coke therefore makes the problem of the air-supply to the cupola a very important one.

Realising the importance of this problem the Compressor Department of the General Electric Company, in co-operation with the Foundry Department has, for the past three years, conducted a series of tests, and made a special study of the air requirement for the cupola. The purpose of this Paper is to describe an automatic blast-gate control for cupolas which ensures the blower delivering a constant weight, not constant volume, of air to the cupola under all conditions. Before describing this apparatus it appears necessary to show why a constant weight, instead of a constant volume of air, is required. Most foundrymen appreciate the advantage of eliminating guesswork from any operation, and for this reason have installed, in the majority of cases, scales for weighing the coke and iron mixture, but have still found it necessary to estimate the air requirements.

What the Blast-Gate Does.

The new automatic blast-gate control has been developed for this purpose by actually weighing the air. So many pounds of air containing so many pounds of oxygen can be delivered to the cupola in order to burn so many pounds of coke in a definite time. This equipment can, therefore, be considered as scales for weighing the air, and the foundryman can determine the proper relation of coke and air to give the best results for any particular condition. The control can then be adjusted so that the blower will automatically deliver the required weight of air for any length of time, irrespective of changes in atmospheric temperatures, barometric pressure, or varying resistance through the cupola.

It is of the utmost importance that after weighing the air proper steps are taken to see that all of it is used in the cupola. The loss should be confined to that escaping through the slag hole. Also, the tuyeres should be continuous to give even distribution all around the cupola, and also of the proper depth to force the air into the centre and eliminate not only the possibility of a cold-spot forming in the centre, but also of the air travelling up the sides.

Special precautions are taken to weigh the coke and iron, and to distribute it properly in the cupola, and it is therefore just as important to take the same precautions with the air, especially when it is realised that the total weight of air used during a heat exceeds the combined weight of coke and iron. Only 23 per cent. of air by weight is oxygen, therefore only this portion fulfils the purpose for which it is introduced and the remaining 77 per cent. works against the melting operation.

Mr. H. V. CRAWFORD, of the (American) General Electric Company, Schenectady, N.Y., who details his researches into cupola control in the accompanying article.

Another important factor when considering the proper distribution of coke, iron and air in the cupola, is that the oxygen of the air must be used up just before it reaches the melting iron in order to prevent oxidation of the iron. The words "just before" should be emphasised for the following reasons. As long as there is oxygen in the air, carbon-dioxide will be formed by the union of the oxygen in the air and carbon in the coke, and every pound of carbon so consumed will develop 14,500 heat units. If the oxygen is completely used up some distance below the melting iron, the carbon-dioxide will pass through the incandescent coke and the carbon in the coke will combine with part of the oxygen in the carbon-dioxide reducing it to carbon-monoxide. This results in a net addition of only 4,450 heat units for each pound of carbon so consumed. In other words, instead of securing 14,500 heat units out of each pound of carbon burned only 4,450 will be secured. This represents a loss of 10,000 heat units, and the coke so burned gives an operating efficiency of only about 31 per cent.

The above illustrates the importance of the proper height of bed. The coke-bed establishes the melting zone, and it should therefore be at such a height that when the proper amount of air is admitted, the oxygen in the air will combine with the carbon in the incandescent coke and form carbon-dioxide just under the first charge of iron. The succeeding charges of iron should be of the same weight as the first, and the charges of coke sufficient to replenish the bed and maintain the melting zone at the same position.

Once the proper relations are determined nothing should be done to disturb the balance. Admitting more air will burn more coke in a given time and possibly increase the rate of melting by burning up the bed, but soon the bed will be so low that the oxygen of the air will come into contact with the melting iron and oxidation will result.

Amount of Air Required.

Theoretically, a pound of pure carbon requires 2.66 lbs. of oxygen for complete combustion. Therefore, in order to burn a pound of carbon 11.517 lbs. of standard air are required. This value is obtained by dividing 2.66 by 0.231, the latter figure being the amount of oxygen contained in a pound of air at standard conditions. One cub. ft. of air at 60 deg. F. and 14.7 lbs. barometric pressure, with an average amount of moisture, weighs 0.0765 lbs., so that this gives 150 cub. ft. of air required to burn 1 lb. of pure carbon.

Assuming a 10: 1 fuel-ratio (excluding the bed, as the amount of coke at the end of the heat usually corresponds to the original bed, and it should therefore be omitted in the calculations), 1 (short) ton of iron requires 200 lbs. of coke for melting, and, therefore, 30,000 cub. ft. of air is required to melt 1 ton of iron. This has been the basis for a great many years for determining the amount of air required, and its use has been accepted so generally as the basis that in a great number of cases the ratio is neglected and the volume is calculated on this basis, even though the amount of coke or carbon may be very much higher. In a large number of cases cupolas are operated with ratios as low as 4 or 5 to 1.

It should be remembered, however, that coke is not pure carbon, so taking this into account and calculating that good coke has about 88 per cent. fixed carbon, only 88 per cent. of the 150 cub. ft., or 132 cub. ft., is required to burn 1 lb. of coke. Therefore, instead of 30,000 cub. ft. being required per ton of iron, only 26,400 cub. ft. is required. This amount is reduced further, due to the fact that even if the proper combination of oxygen and carbon may have taken place in the melting zone and carbon dioxide is formed, this gas, in passing through the upper layers of coke, takes up some of the carbon, and therefore the amount of oxygen required in the melting zone is further reduced.

Assuming that the amount of carbon taken up by the carbon dioxide in poor practice may be as high as two-thirds of the carbon in every lb. of coke, the air required would be $\frac{1}{3}$ times 0.88 times 150, or 44 cub. ft. This is, no doubt, what happens when the iron-to-coke ratio is very low. In good practice only $\frac{1}{8}$ of the carbon may be taken up by the carbon dioxide, so that $\frac{3}{8}$ times 0.88 times 150, or 88 cub. ft. would be required. Under the best of conditions it is possible that this value may be as low as 1/7, so that the air required would be 6/7 times 0.88 times 150, or a maximum of 113 cub. ft.

Effect of Wetting Coke.

Some of the carbon consumed by the carbon dioxide, of course, is bound to take place in the bed, but with the bed of proper height this inefficient burning of the coke is confined to the layers of coke above the melting zone. Wetting the coke is standard practice in some plants, but it is questionable how much good this does, as surely the coke cannot move down the cupola a very great distance before the heat from the rising hot gases drives off the water in the coke.

The above figures do not allow anything for leakage, as with the proper installation the leakage should be confined to that escaping through the slag hole, as the pipe should be so installed, the cupola properly formed, and the proper construction of blast gate used to eliminate any possibility of air leaking. It is impossible to calculate correctly the leakage through the slag hole, as this varies during the heat. Also, this does not allow anything for air travelling up the sides of the cupola, but this will be almost negligible if the tuyeres are of the proper height to give the proper velocity to the air so that it will travel further into the centre.

Some margin, of course, should be allowed; and allowing, therefore, approximately 120 cub. ft. of standard air per lb. of coke, or 24,000 cub. ft. of air per ton of iron, has been found by test to give a sufficient margin.

This has been the basis of recommendations on certain types of blowers for years, and it has been proved by actual practice to be a very good basis from which to work in estimating the volume of air required under normal conditions of 60 deg. F. and 14.7 barometer.

Calculating on this basis for a 10: 1 ratio, 24,000 cub. ft. per ton of iron is all that is required instead of 30,000. If the latter figure is used, 25 per cent. too much air or 25 per cent. too much oxygen is introduced to exist as free oxygen and oxidise the iron. Also, 25 per cent. more inert gas is introduced to help to retard the melting operation.

Blowers are rated in terms of cub. ft. of air per min. at 60 deg. F. and 14.7 barometer, and on the basis of approximately 120 cub. ft. at 60 deg. F. and 14.7 barometer required for each lb.

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* A Paper read before the National Founders' Association, N.Y. City, Nov. 21, 1928. The author is associated with the Industrial Department of the General Electric Co., Schenectady, N.Y.

of coke burned, the following formula can be used:—

$$\frac{120 \times 2{,}000 \times T}{60 \times R} = \text{the cub. ft. per min. required.}$$

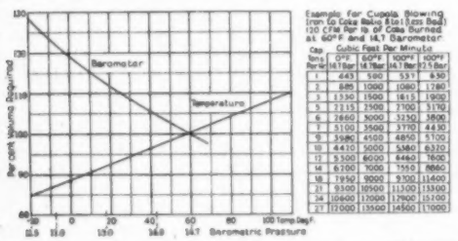
This makes it possible to select the correct capacity blower. In this formula T equals the tons of iron per hour, R equals the ratio of iron to coke, excluding the bed. This formula will reduce to $\frac{4{,}000 \times T}{R}$ – which is simple and easy to remember.

In arriving at a value of R, which is the ratio of iron to coke, it is found that in a large number of cases this is based on the total amount of iron charged divided by the total amount of coke charged, including the bed, and in other cases the total iron divided by the amount of coke exclusive of the bed. The latter method is more nearly correct, as the amount of coke left unburned is approximately equal to the amount of the original coke-bed less the amount burnt in melting the last charge of iron.

Constant Weight Superseding Constant Volume as Basis.

The previous calculations have been based on the weight of air at standard conditions of 14.7 and 60 deg. Fah., but conditions are not always standard, as the air temperature will vary from below zero to 100 deg. Fah. in certain [American] localities. The barometer will also vary, and in some districts, on account of the altitude, will be very low. The weight of a certain volume of air will, therefore, change with the temperature and barometer, and therefore blowers should be operated to give, not constant volume, but constant weight.

Using the previous calculations as a basis to start from, and calculating that the weight of a cubic foot of air varies directly with the barometric pressure and inversely with the absolute temperature, the volume required at various temperatures and barometric pressures can be determined. A blower that can be operated to give a varying volume between minimum and maximum requirements and maintain the weight of air constant should therefore be used. The variation in volume to give constant weight for varying atmospheric conditions is shown in Fig. 1.



Example for Cupola Blowing Iron to Coke Ratio 8 to 1 (Less Bed) 120 C/M Per Ton of Coke Burned at 60° F and 14.7 Barometer

Cap. Tons Per Hr.	Cubic Feet Per Minute 60°F 14.7 Bar	60°F 14.1 Bar	100°F 14.7 Bar	100°F 13.5 Bar
1	445	500	537	650
2	885	1000	1080	1280
3	1330	1500	1615	1900
5	2215	2500	2700	3170
6	2660	3000	3230	3800
7	3100	3500	3770	4430
9	3980	4500	4850	5700
10	4430	5000	5380	6320
12	5300	6000	6460	7600
14	6200	7000	7550	8860
16	7950	9000	9700	11400
20	9300	10500	11300	13300
24	10600	12000	12900	15100
27	12000	13500	14500	17000

FIG. 1.—VOLUME OF AIR REQUIRED AT VARIOUS TEMPERATURES AND BAROMETRIC PRESSURES FOR A CONSTANT WEIGHT OF OXYGEN. STANDARD CONDITIONS OF 60 DEG. F., AND 14.7 LBS. BAROMETER.

Effect of Temperature.

For example, in the summer time, with the temperature at 100 deg. Fah., and atmospheric pressure at 14.7, the volume figured at 60 deg. Fah. and 14.7, will expand in the ratio of the absolute temperatures, or $\frac{460+100}{460+60} = 1.075$. Therefore, in order to get the original weight of oxygen calculated, the volume of air should be increased 7.5 per cent. Otherwise, if constant volume is maintained, there will not be enough oxygen for proper combustion. In the winter time, or at zero degrees, the volume figured at 60 deg. will contract in the ratio of $\frac{460}{520} = 0.885$. Therefore, in order to get the original weight of oxygen calculated, the volume of air should be reduced 11.5 per cent.

Calculating, therefore, on the basis of 120 cub. ft., or 24,000 cub. ft. per ton of iron at 60 deg. Fah., at 0 deg. Fah., this volume should be 0.885×120, or 106 cub. ft., or 21,200 cub. ft. per ton of iron. At 100 deg. the volume should be 1.075×120, or 129 cub. ft. per lb. of coke burned, or 25,800 cub. ft. per ton of iron. This means an increase from zero degrees to 100 deg., or 22 per cent. in the volume.

Effect of Barometer.

The previous paragraph does not take into account the variation in barometer, which at sea-level will be a maximum of 7 per cent., or from 15.2 to 14.2 lbs. (31 to 29 in. Hg.). The maximum variation in volume will therefore be from 0 deg. Fah., at 15.2 lbs., barometer to 100 deg. Fah. at 14.2 lbs. barometer. The 105 cub. ft. previously calculated at 0 deg. Fah. will, therefore, be reduced in the ratio of $\frac{14.7}{15.2}$, or to 102.5 cub. ft. (20,500 cub. ft. per ton of iron), and the 129 cub. ft. at 100 deg. will be increased in the ratio of $\frac{14.7}{14.2}$, or to 133.5 cub. ft. This means, therefore, an extreme variation in volume from 102.5 to 133.5 or 30 per cent.

Effect of Humidity.

Under ordinary circumstances, the air handled by a cupola blower will carry a small amount of water vapour. If, however, due to weather variations, this humidity of the atmosphere changes, there will be a change in the density of the air, which in turn alters the percentage of oxygen-constant. This will cause an error at one extreme, when no water vapour is present at all, of 0.3 of 1 per cent. and at the other extreme, on a very hot, humid day, of 1.5 per cent. This gives a range between complete dryness and maximum humidity of nearly 2 per cent.

In the previous paragraphs, the minimum requirement in volume has been figured at 0 deg. Fah., and 15.2 lbs. barometer pressure, as 102.5 cub. ft. per lb. of coke, or 20,500 cub. ft. per ton of iron. Taking into account humidity for the minimum volume, this would be at the extreme of complete dryness, and the 0.3 of 1 per cent. would have no appreciable effect on the above values.

Total Effect.

The above figures show that a very serious error is made when the air required is calculated on the old basis of 150 cub. ft. of air per lb. of coke, or 30,000 cub. ft. per ton of iron for all conditions of the intake air. At the minimum conditions of 0 deg. Fah., 15.2-lbs. barometer, and complete dryness, the excess air, or oxygen, will equal the difference between 30,000 and 20,500 cub. ft., or 46.5 per cent.

It follows that if there was a perfect device for supplying a cupola with a constant volume of air, and if this volume were exactly correct at one extreme, it would be seriously erroneous at the other extreme. Certain types of blowers and air meters have been developed, with the idea of securing this constant volume, but even the most perfect operation of these machines and meters will give the serious discrepancies illustrated at one extreme or the other.

Effect of Excess Oxygen.

For perfect combustion a definite weight of oxygen should combine with a definite weight of carbon in the coke to give carbon-dioxide gas in the melting zone, so that if too much oxygen is supplied free oxygen will exist and combine with the iron in the melting zone, and the result is oxidised or burnt iron. Also, the excess oxygen carries more nitrogen, and this increases the cooling action so that the iron is not only burnt, but is cold. Of the air, 23 per cent. is oxygen, which is the agent promoting combustion, and the remaining 77 per cent. is largely nitrogen and inert gas, which is heated to the maximum temperature in the cupola, and then escapes into the atmosphere; but because it passes through the successive layers of iron and coke at such a high velocity, it only has sufficient time to transmit a small percentage of this heat.

Excess oxygen, therefore, means not only oxidised, but cold and spongy iron.

Effect of Insufficient Oxygen.

Insufficient oxygen indicates that the oxygen is totally consumed in combining with the coke in the lower part of the layer of coke just at the melting zone. Carbon-dioxide is formed, but insufficiently, and also it encounters the incandescent upper part of the layer of coke just under the melting iron, and is converted into carbon-monoxide gas. This occurs in the regions just where the highest temperature to be secured by forming carbon-dioxide is required. The result is cold iron and slow melting with the possibility of bridges forming.

Effect of Pressure.

Before discussing the proper method of control reference should be made to the part the air pressure plays in the melting operation. In some cases the practice has been to hold constant pressure on the wind box, this is entirely wrong as the resistence to the flow of air through the cupola will vary, and, therefore, the pressure on the wind box should vary. Also the volume will change with variations of temperature and barometer and the pressure on the wind box must be increased to force a greater volume through the cupola. Pressure, therefore, has no relation to the operation other than being the agent for forcing the proper amount of air or oxygen into the cupola. However, it is well to remember that for large size cupolas additional pressure must be available in order to force the air through the tuyeres at a great velocity, and therefore carry them into the centre of the cupola and to overcome greater cupola-resistance due to the higher charging doors. If a cold spot is forming in the centre this means that the air is passing up around the side and is not penetrating to the centre, and, therefore, the height of the tuyeres should be cut down. Then, of course, the higher pressure is required to force the same amount of air through the effective area, and this increases the velocity of the air and it penetrates further into the cupola.

(To be continued.)

Scottish Malleable Iron Trades Wages Dispute.

Following upon the deadlock between employees in Scottish manufactured iron trade and the Iron and Steel Trades Confederation regarding wages and hours, the employers have now posted notices intimating that after January 26 the wage reductions and longer hours would be enforced or the works will stop operations. Seven Scottish works are involved, but should a stoppage result other industries might be affected. It is understood that the matter is being raised in the House of Commons with a view of having the rules of the Board of Conciliation and Arbitration enforced.

Moulders' Strike Ballot.

The strike of rain-water moulders, which has been in progress since the beginning of the year, and affects about 3,000 men employed in the light castings industry, is to continue.

The ballot on the question of accepting a reduction of 5 per cent. in the wages bonus has resulted as follows:—

For continuing the strike	...	905
For acceptance of reduction	...	781
Majority for continuing strike		124

Of the 3,000 men affected, approximately 1,000 are employed in the Falkirk area. Three Trade Unions are implicated—the Central Ironmoulders' Association, the National Union of Foundry Workers, and the Stove and Grate Fitters' Union.

Contributions to Charities.

The employees of Messrs. Cruickshank & Company, Limited, Denny Iron Works, have contributed to Glasgow and Falkirk Infirmaries £45 10s. The employees of Messrs. Babcock & Wilcox, Limited, Dumbarton Works, have contributed during the last six months to Glasgow Infirmaries £186.

Design of Engineering Castings in Relation to Tests.*

By J. G. Pearce, M.Sc., M.I.E.E. (Director, B.C.I.R.A.).

It is not intended to refer at any length to the question of design in relation to patternshop and foundry practice. There is much to be done in making engineering designs metallurgically sound, because the engineer tends to specify what he wants without regard to foundry necessities and the founder tries to make it. Modification is usually only made in case of failure. All that founders can do is continually to stress in a general way the advisability of uniform sections, gradual changes in section, rounded corners, avoidance of small cores and feather edges of sand, and so on. These matters have been discussed on several recent occasions.

The purpose is rather to raise the question of the empirical nature of the present basis of calculation in cast-iron design with a view to suggesting some methods of making it more scientific. The proposals form a method of treatment only; they are not intended for general application. In the present state of the knowledge of cast iron it is necessary for each foundry to determine for itself the relation between strength and section and strength and composition for its own mixtures.

Basis of Design.

Since, for most engineering castings, it is impracticable to take test-bars from actual castings or to test castings themselves, the necessary data for design have to be derived from the test-bar. The shape and size of a casting are determined partly by the strength of the material and partly by the stresses it has to meet in service. A design can only be scientific when these two factors are known with some exactitude. Even with ductile materials, service stresses are so complex that the most scientific type of design is still to some extent empirical, based upon experience and upon knowledge of failures. Partly owing to the wide variety both in shape and size of test-bars in use and partly to the difficulty of relating a given size of test-bar to a casting which has a larger mass and a varying section, cast-iron design is still more empirical. This difficulty is made worse by the practice of calling for the test-bar to be cast as an integral part of the casting, for the inherent cooling rate of the test-bar itself is modified to a quite incalculable degree by the position of the bar in relation to the cooling mass of the casting and by their respective sizes.

Fortunately, the issue of the recent B.E.S.A. Specification No. 327 for grey cast iron has simplified and standardised test-bars to some extent. The specification enables a test-bar, round in section, to be cast away from the casting and having a diameter comparable with the section of the casting itself. In the absence of statements to the contrary, the tests dealt with in this Paper refer to bars cast in accordance with the conditions laid down in the specification.

The uncertainty of the design basis for cast iron is responsible in part for the very large factor of safety required for cast iron. If by rationalising casting design, one can ensure the minimum weight to be used for the service indicated without sacrificing essential properties, there should be a saving to the industry not only in first cost, but in transport costs, a factor of great importance in export work. In engineering castings mere tonnage is not the primary consideration.

The adoption of the new specification will mean the abandonment by engineers of the 2-in. by 1-in. rectangular bar and the 1-in. sq. Admiralty bar. The Cast Iron Research Association has shown[1] that the square bar is definitely weaker per unit of area than the round bar of similar area not on account of the different modes of crystallisation of the bars, but on account of the differences in stress distribution across the bar during the test. The difference in favour of the round bar may be as much as 10 to 20 per cent.

Test Ratios.

Some approximate figures are given in this Paper for ratios between certain tests for cast iron with a view to enabling the results of one test to be compared with those of another. These ratios are not intended at this stage as precise figures or to justify any particular type of test being abandoned. They provide a means for checking one test result against another.

Some figures are also given showing the variation of strength with section. In the case of the transverse test the figures have been obtained on the cast section, although it is preferable to skin-machine the bars, removing about 1-16 in., or in the case of medium-sized bars 1-10 in., to preclude erratic results due to the presence of small surface cracks from the green-sand mould. In the case of the tensile test, machining the gauge length is, of course, essential, and the values obtained from this test depend to some extent on the amount machined away. In the case of compression, torsion, shear and impact tests it is necessary to machine all bars to one size, as it is impracticable to provide a range of testing machines for testing different sections. Speaking very generally, the central core, say, ½ in. dia., of a series of bars of varying cast diameters will vary in structure and hence in strength, the largest bars being the most open and weak at the centre.

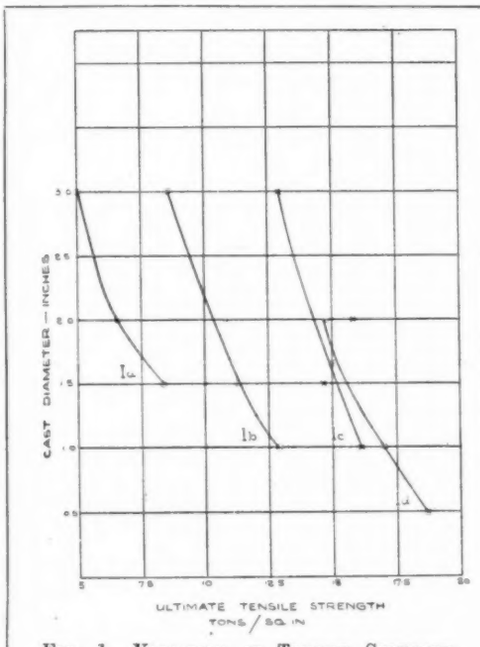


FIG. 1.—VARIATION OF TENSILE STRENGTH WITH CAST DIAMETER.

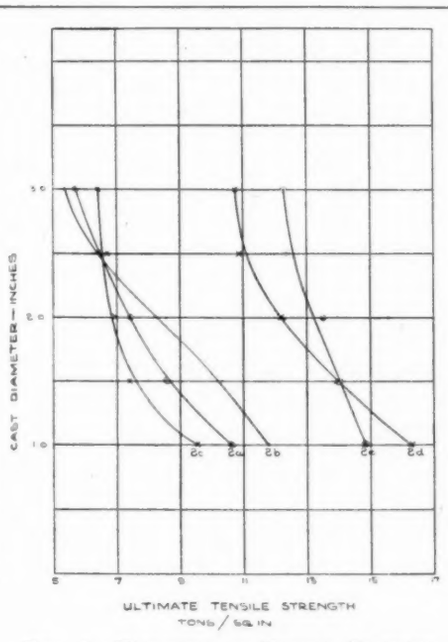


FIG. 2.—VARIATION OF TENSILE STRENGTH WITH CAST DIAMETER, FROM DATA BY ROTHER AND MAZURIE.

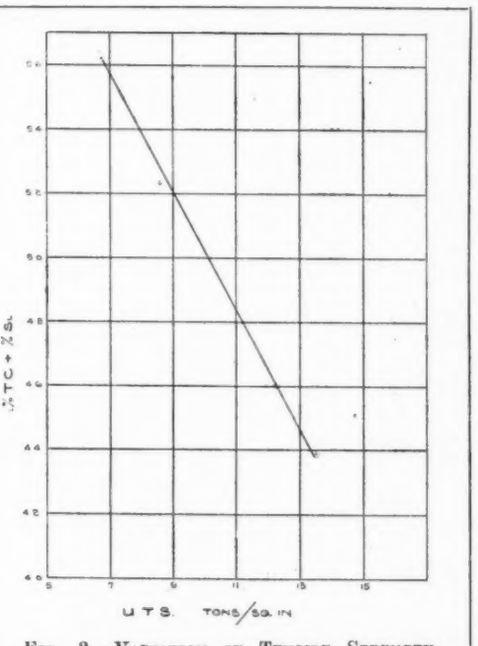


FIG. 3.—VARIATION OF TENSILE STRENGTH WITH COMPOSITION, FROM FIG. 2.

Tensile Test.

This test is very familiar to engineers, although, in the case of cast iron, no elongation or yield point is recorded. Care is required to ensure axial loading. The variation of tensile strength with cast section is shown in Fig. 1, which represents three irons, the analyses of which are given in Table I, and actual tensile values in Table II. The fourth curve, 1*d*, shows some figures taken from a number of American tests, and is inserted to show the same general tendency. In curves 1*a*, 1*b* and 1*c*, the 2-in. and 3-in. bars were reduced to 0.798 in.; 1-in. and 1½-in. bars to 0.564 in. The increase in strength, it will be noted, follows a diminishing graphite and silicon content, but as the four series were cast in different foundries, no

It seems reasonable to suggest that variations in strength of cast bars can be followed by testing the central core, which correspondingly varies in structure. Whether results so obtained follow exactly those obtained on the actual cast bars has yet to be proved, and this will provide an interesting investigation. A series of transverse bars of differing diameters could be cast in duplicate, one set tested as cast, the other machined to, say, ½ in. dia. in each case and then tested.

* A Paper read before the South Wales and Monmouth Branch of the Institute of British Foundrymen at the Merchant Venturers' Technical College, Bristol, December 1, 1928, Mr. B. Hird presiding.

[1] Norbury, B.C.I.R.A., Bulletin No. 21, and FOUNDRY TRADE JOURNAL, November 1, 1928.

attempt is made to connect composition and strength.

Table I.—*Analyses of the Irons shown in Figs.* 1-11.

Bar Series.	Analysis.						
	T.C.	C.C.	G.C.	Si.	Mn.	S.	P.
1a	3.16	0.23	2.93	4.07	0.84	0.02	1.08
1b	3.44	0.72	2.72	1.31	0.48	0.09	0.58
1c	3.20	0.74	2.46	0.94	0.66	0.12	0.83
1d	From A.F.A. Tests.						
2a	3.35	0.52	2.83	2.15	0.65	0.07	0.47
2b	3.53	0.68	2.85	1.70	0.85	0.11	0.44
2c	3.52	0.54	2.98	2.10	0.65	0.10	0.34
2d	3.29	0.64	2.65	1.10	0.90	0.06	0.11
2e	3.40	0.70	2.70	1.20	0.90	0.11	0.31
4a	3.55	0.72	2.83	1.63	0.72	0.05	0.28
4b	3.34	0.75	2.59	1.19	0.59	0.12	0.98
4c	3.52	0.70	2.82	1.45	0.64	0.08	0.38
4d	From A.F.A. Tests.						
5a	3.14	—	—	2.66	0.55	0.06	1.19
5b	3.42	—	—	1.55	0.55	0.08	0.49
7a	3.62	0.82	2.80	1.53	0.75	0.07	0.88
7b	3.64	0.84	2.80	1.03	0.58	0.06	0.42
11a	3.52	0.70	2.82	1.45	0.64	0.08	0.38
11b	3.55	0.72	2.83	1.63	0.72	0.05	0.28

The machining of the tensile test-bar results in this test showing less change with section than other tests, and it is suggested that, in order to get the least possible variation with most consistent results, and to show the closest possible relationship between transverse and tensile strengths, the tensile test should be taken on a bar from which a minimum of metal has been machined. It is suggested that cast-iron tensile test-bars should not be machined down to a predetermined figure like 0.564 in. and 0.798 in. standard diameters, which gives a convenient area of bar, but that, whatever the cast size, the minimum should be machined off capable of giving a break in the gauge length.

Table II.—*Tensile Values of the Three Irons shown in Fig.* 1.

Bar Series.	Ultimate Tensile Strength in tons/sq. in. at Cast Diameter.					
	3 in.	2 in.	1.65 in.	1.5 in.	1.0 in.	0.5 in.
1a	5.04	6.6	—	8.3	—	—
1b	10.1	10.7	—	11.2	13.8	—
1c	12.9	15.8	—	14.7	16.1	—
1d	—	14.8	15.0	—	17.0	18.65

Fig. 2 shows a series of curves of the variation of cast section with tensile strength, from data published by Rother and Mazurie.[2] The tensile values are given for convenience in Table III. All these bars were turned down to 0.875 in. diameter for the tensile test. This series is of particular interest in that all the bars were cast in the same foundry, but from different mixtures. The analyses are given in Table I, and Fig. 3 shows the variation of tensile strength with total carbon

Table III.—*Tensile Values from Rother and Mazurie's Tests.*

Bar Series.	Ultimate tensile Strength in tons/sq. in. at Cast Diameter.				
	3in.	2.5in.	2 in.	1.5in.	1 in.
2a	5.65	6.5	7.3	8.6	10.6
2b	5.35	6.3	8.6	10.35	11.6
2c	6.35	6.75	6.85	7.4	9.5
2d	12.25	12.4	13.5	13.8	16.2
2e	10.75	10.9	12.2	13.8	14.7

[2] Rother and Mazurie, "The Strength of Cast Iron in Relation to its Thickness." Transactions, American Foundrymen's Association, 1926, Vol. 34, p. 746.

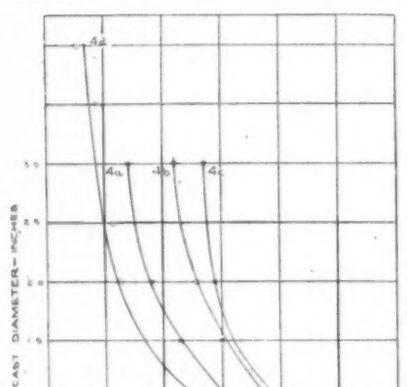


Fig. 4.—Variation of Compression Strength with Cast Diameter.

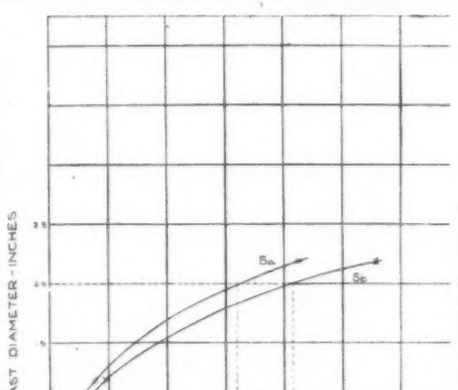


Fig. 5.—Variation of Transverse Breaking Load and Diameter.

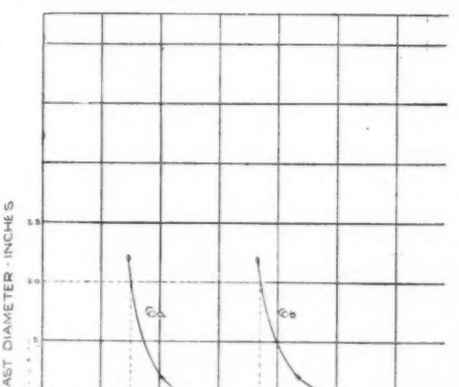


Fig. 6.—Variation of Transverse Breaking Stress and Diameter.

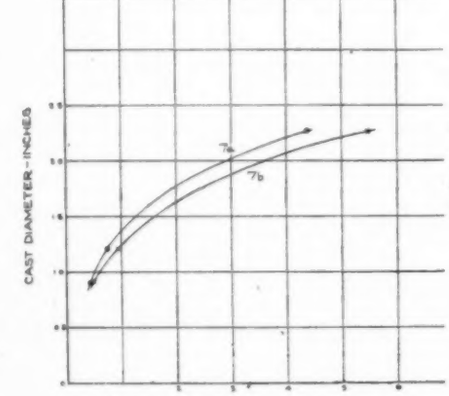


Fig. 7.—Variation of Transverse Breaking Load with Diameter.

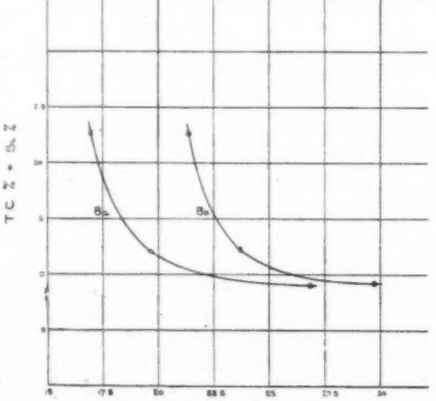


Fig. 8.—Variation of Transverse Breaking Stress and Diameter.

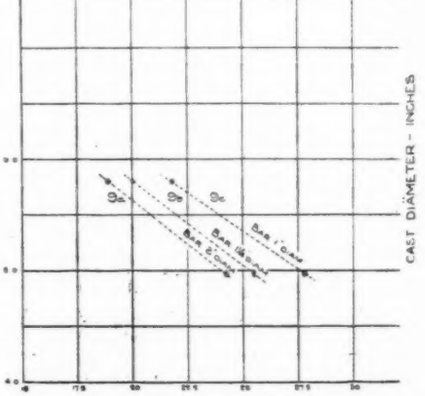


Fig. 9.—Variation of Transverse Rupture Stress and Composition.

+ silicon. The author has elsewhere[3] dealt with the choice of total carbon + silicon as a criterion of composition, and it is not proposed to go into the matter here except to say that the points in Fig. 3 lie so closely on a straight line that this offers *prima facie* evidence of the suitability of the sum for cupola-melted irons.

Compression Test.

The compression testing of cast iron was formerly much more common than is the case to-day but as a routine test it is scarcely practicable. The variation of compression strength with size is shown for a series of samples in Fig. 4, the actual figures being given in Table IV, and analyses in Table I. In curves 4*a*, *b* and *c*, the compression test piece was a cylinder 0.564 in. diameter and 1.128 in. high; 4*d* is from a series of early American tests.

TABLE IV.—*Compression Values of Irons shown in Fig.* 4.

Bar Series.	Ultimate Compressive Strength in tons/sq. in. for Cast Size.				
	3 in.	2 in.	1.5 in.	1 in.	0.5 in.
4a	33.4	37.7	42.5	53.4	64.4
4b	41.8	45.3	53.4	57.2	66.5
4c	46.7	48.4	49.9	59.4	79.2

Improvements in the tensile strength of cast iron in recent years have rendered the compression: tensile ratio a little less than formerly. At one time it was about 5; to-day it may, with greater accuracy, be taken as 4.

Transverse Test.

This test is so simple and so popular that it is not likely to be superseded as a strength test for cast iron. It is usual to express the result of the transverse test as a breaking load and deflection, but if this is done without reference to the actual size of the bar, a wrong impression may be given, for the strength of cast iron changes very quickly with small changes in bar section. It is notoriously difficult to cast accurately a bar to a given size.

The practice of converting breaking load on a cast size to the breaking load on a specified size is also liable to introduce a serious error, for if the cast size is greater than the specified size, the slower cooling of the heavier bar will make the cast bar relatively weaker than the specified size bar would have been.[3] On the other hand, if the cast size is less than the specified size, the cooling will be quicker and the bar relatively stronger than the specified size would have been. These points can be illustrated in the following way. Supposing one makes from one melt the three standard test bars 0.875 in., 1.2 in. and 2.2 in. diameter, and tests them in transverse at 18 in. centres. It is preferable to cast a bar about 1.7 in. diameter, also to fill the considerable gap between 1.2 in. and 2.2 in. The breaking load can be plotted against diameter as shown in Fig. 5. Curve 5*a* is for one iron and curve 5*b* for another iron from the same foundry, the analyses being given in Table I. These irons differ not only in total carbon and silicon, but also in phosphorus. the curve for the lower silicon iron 5*b* therefore showing greater breaking loads than 5*a*. For convenience the actual breaking loads in tons are given in Table V.

It is reasonable to suppose that the change in breaking load is regular with size and consequently it is practicable to tell from Fig. 5 the breaking load for any cast diameter up to 2.25 in.

TABLE V.—*Breaking Loads of the Irons given in Fig.* 5.

Bar Series.	Transverse Breaking Load in tons at 18 in. Centres on Cast Diameter.		
	0.875 in.	1.2 in.	2.2 in.
5a	0.37	0.74	4.25
5b	0.45	0.95	5.55

Thus it would be expected that 1-in. bars of 5*a* and 5*b* respectively would break at 0.5 and 0.6 tons, while 2-in. bars would break at 3.2 and 4.15 tons. Since a 2-in. bar is only four times the area of a 1-in. bar, it might seem superficially that the 2-in. bar is the stronger in each case, but it must be remembered that we are dealing not with a tensile but with a transverse stress, for transverse stress varies inversely not as the square of the diameter (*i.e.*, as the area) as in the tensile test, but as the cube. This really shows one reason why the simple representation of size and breaking load is inadequate.

In working out the transverse rupture stress in tons per square inch for each of these bars, this is done on the round bar by means of the simple formula,

$$f = \frac{WL}{0.39d^3}$$

where W is the breaking load,
L the span in inches,
d the diameter in inches.

f is then the transverse rupture stress in tons or lbs. per sq. in., according as W is in tons or lbs.

The simple method of expressing transverse strength as breaking load without reference to diameter of cast bar assumes that d is cast always exactly the specified size, which, of course, is not the case. The conversion method assumes that f is the same at different diameters of bar, which, as will be shown, is also not the case.

The calculation of the breaking stress in tons per sq. in. is more complicated for the transverse test than the corresponding one for the tensile test, and can be avoided by the use of a graphical chart. Fig. 12[4] shows such a chart for the standard 1.2 in. and 2.2 in. bars together with oversize and undersize variations permitted by the B.E.S.A. specification. It will be evident that any breaking load on each of the five diameters for each standard bar can be converted at sight into actual transverse rupture stress. The striking difference in rupture stress for the same load on varying sizes for one diameter is shown very clearly. Thus a breaking load of 10,000 lbs. on a 2.3-in. bar gives a rupture stress less than 17 tons per sq. in., whereas the same load on a 2.1-in. bar gives over 22 tons

[3] Pearce, "The Use and Interpretation of the Transverse Test for Cast Iron." "Journal, Iron and Steel Institute," 1928, II, Discussion.

[4] Reproduced by permission from Pearce, "Engineer," October 19, 1928.

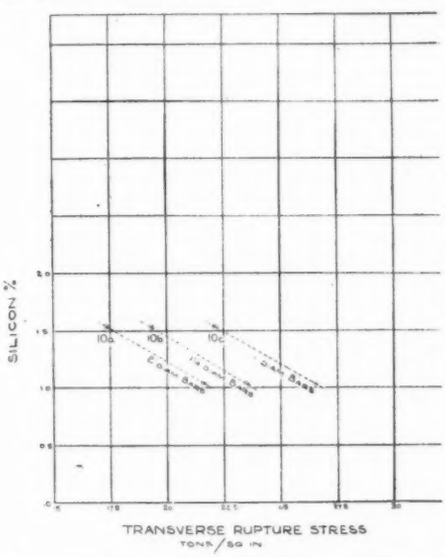


FIG. 10.—VARIATION OF TRANSVERSE RUPTURE STRESS AND COMPOSITION.

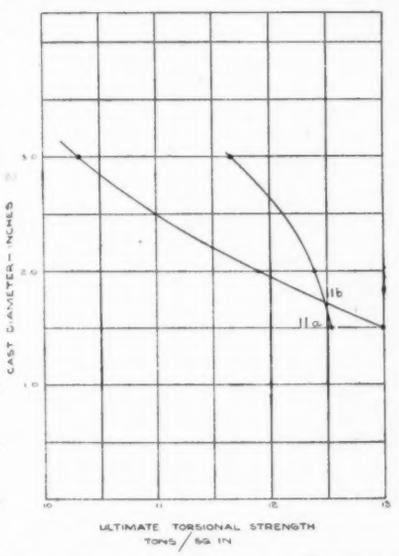


FIG. 11. — VARIATION OF TORSIONAL STRENGTH AND CAST DIAMETER.

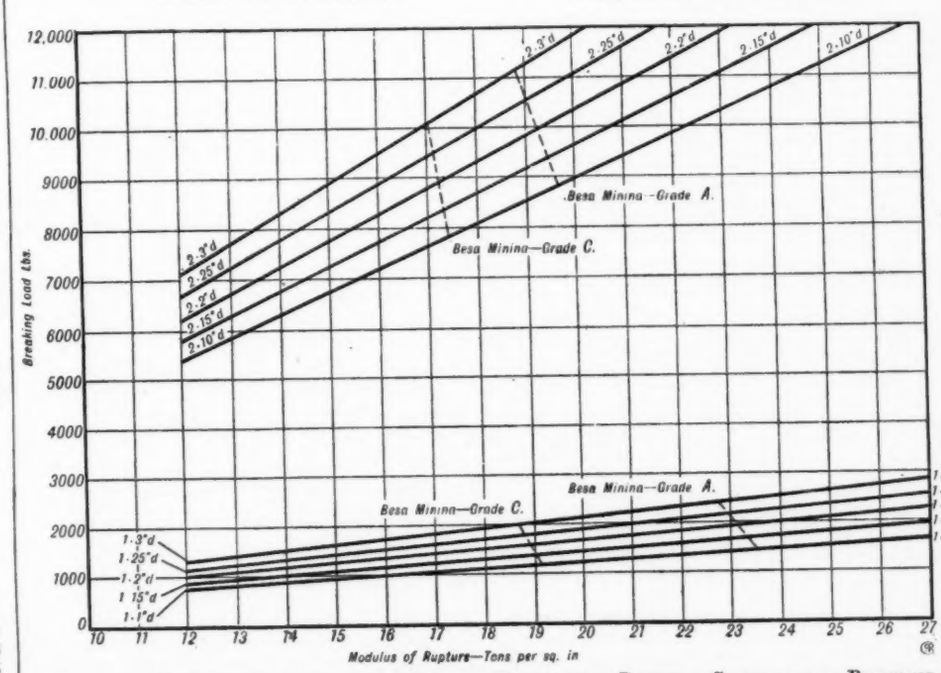


FIG. 12.—CONVERSION CHART FOR OBTAINING TRANSVERSE RUPTURE STRESS FROM BREAKING LOAD FOR 1.2- AND 2.2-IN. BARS.

per sq. in. On the specified size it is 19.4 tons per sq. in.

Size-Strength Curves.

In Table VI. are given the rupture stresses for the breaking loads shown in Table V., and the curves of diameter and rupture stresses are shown in Fig. 6. It is now seen that 1-in. bars of *a*

TABLE VI.—*Rupture Stresses for the Breaking Loads shown in Fig. 5.*

Curve.	Bar Series.	Transverse Rupture Stresses in tons/sq. in. at 18 in. Centres on Cast Diameter.		
		0.875 in.	1.2 in.	2.2 in.
6a	5a	24.9	20.2	18.7
6b	5b	30.3	25.8	24.2

and *b* respectively would withstand 21.5 and 27.75 tons per sq. in., while the 2-in. bars would withstand 18.75 and 24.25 tons per sq. in. in each case, a drop of 2.6 tons per sq. in. for *a* and 3.5 tons per sq. in. for *b*. Thus the specific stress on a transverse bar increases as the bar diameter diminishes, as shown in Fig. 6, and consequently ordinary static tests do not and cannot measure, at any rate, directly.

Composition-Strength Curves.

It will be noticed that in both Figs. 6 and 8 the curve for the stronger iron is lower in silicon and this fact enables a first approximation to be made between strength and composition. Suppose one takes from Figs. 5 and 6 the strengths for 1-in. bars, 1½-in., and 2-in. bars and plots them against composition, given in Table I. The result is given in Fig. 9, and for Figs. 7 and 8 in

TABLE VIII.—*Rupture Stresses for the Breaking Loads shown in Fig. 7.*

Curve.	Bar Series.	Transverse Rupture Stresses in tons/sq. in. at 18 in. Centres on Cast Diameter.		
		0.875 in.	1.2 in.	2.2 in.
8a	7a	26.8	19.7	17.0
8b	7b	29.8	23.7	21.4

Fig. 10, although in Fig. 10 the irons are so similar in total carbon that silicon alone is used as an index to composition. It must again be

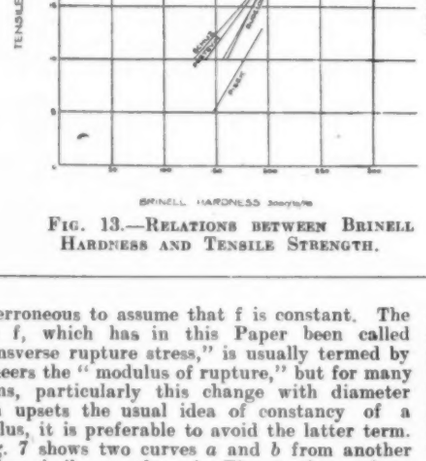


FIG. 13.—RELATIONS BETWEEN BRINELL HARDNESS AND TENSILE STRENGTH.

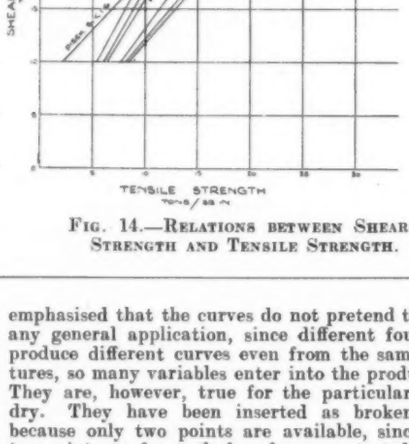


FIG. 14.—RELATIONS BETWEEN SHEAR STRENGTH AND TENSILE STRENGTH.

it is erroneous to assume that f is constant. The value f, which has in this Paper been called "transverse rupture stress," is usually termed by engineers the "modulus of rupture," but for many reasons, particularly this change with diameter which upsets the usual idea of constancy of a modulus, it is preferable to avoid the latter term.

Fig. 7 shows two curves *a* and *b* from another foundry similar to those in Fig. 5, the analyses being given in Table I and loads in Table VII.

TABLE VII.—*Breaking Loads of the Irons given in Fig. 7.*

Bar Series.	Transverse Breaking Load in tons at 18 in. Centres on Cast Diameter.		
	0.875 in.	1.2 in.	2.2 in.
7a	0.43	0.74	4.33
7b	0.49	0.94	5.46

Fig. 8 shows the transverse rupture stress against diameters for the same two irons, similarly to Fig. 6, the actual values being given in Table VIII. It is interesting to note that for a given difference between mixtures the difference between strengths is less pronounced between thin than between thick bars. Curves 5, *a* and *b*, for instance, show that the smallest test bars have their strength more nearly alike than the largest bars and the change is progressive. This is often found to be the case, but it must not hastily be concluded that for thin castings any iron is as good as any other iron. There are many properties of castings which

emphasised that the curves do not pretend to have any general application, since different foundries produce different curves even from the same mixtures, so many variables enter into the production. They are, however, true for the particular foundry. They have been inserted as broken lines because only two points are available, since only two mixtures for each foundry were tested. One or more additional mixtures would probably show that the curves are not straight lines. The author's object in showing these incomplete diagrams is to stimulate founders to cast bars in a range of sizes for each of several mixtures so that a reliable set of curves may be obtained for each foundry. They would act as a basis for estimating whether the product was above or below standard and for testing new brands of iron and so forth.

There are other reasons for expressing the transverse strength of a cast-iron bar in terms of rupture stress in tons per square inch, apart from that given above. Comparison between transverse bars of almost the same section and same shape is only practicable if this is carried out. Furthermore, a relation appears between tensile and transverse strength when the latter is so expressed. The transverse: tensile ratio is 1.8 to 2, and this could probably be made still more accurate if tensile values were carefully taken on bars from which the same amount of metal had been removed. The figure mentioned applies to separately cast round bars, and if the transverse-tensile ratios are worked out from figures given in B.E.S.A. Specification 327 the figures all fall between 1.8 and 2.1, and, what is still more remarkable, the ratios are the same in Grades A and C, although slightly different in the different sizes, a difference that may well be due to the varying amounts removed for the tensile test.

Finally, it may be emphasised that the breaking load at the centre of a transverse bar depends upon span as well as diameter and composition. The figures obtained from the B.E.S.A. standard bars, 0.875 in. diameter at 12 in. centres and the 1.2 in. diameter at 18 in. centres cannot be compared on account of the span difference, and thus valuable information is obscured.

Shear and Torsion Tests.

Fundamentally shear and torsion stresses, like transverse stresses, are capable of being resolved into tensile and compressive stresses. The torsion test, results of which correlate best with what would be expected from theoretical considerations, is obtained on a thin hollow tube, and obviously such a test is not likely to find any routine application. The variation of torsion strength with section is shown in Fig. 11, corresponding analyses being given in Table I, the torsion test pieces being reduced to 0.75 in. diameter in all cast sizes. The actual test figures are given in Table IX.

TABLE IX.—*Torsional Strength for Irons shown in Fig* II.

Bar Series.	Ultimate Torsional Strength in tons/sq. in. on Cast Sizes.		
	3 in.	2 in.	1½ in.
11a	10.3	11.9	13
11b	11.65	12.4	12.55

Torsion test results, like transverse test results, are seldom expressed in a manner which enables comparisons to be made with other test results. The twisting moment T is usually given in inch tons. T is related to the ultimate shear stress f_s within the elastic limit by the formula:

$$T = \frac{\pi d^3 f_s}{16}$$

where d is the diameter of the bar. When T is increased beyond the elastic limit, f_s ceases to be proportionate to the distance from the axis and becomes practically uniform over the section, in which case

$$T = \frac{\pi d^3 f_s}{12}$$

The torsion strength is approximately 1.1 or 1.2 times the tensile strength, although the absence of any standardised method of testing torsion precludes any definite conclusion on this point.

Shear testing is a much more practicable form of testing than the torsion test, and can be done either on a plate or on a rod. Both require very accurate machining, and the actual shear figure obtained does not appear to be an absolute value but depends on whether the test is done in single shear or double shear, and upon the testing procedure adopted. If the procedure is carefully standardised the test appears to give quite consistent results, but compared, for example, with the transverse test, it does not afford any subsidiary indication, such as deflection, and the accurate machining required adds to its inconvenience as a routine test. The shear strength varies from 1.2 to 1.8 times the tensile strength.

Fatigue Tests.

Designers who have to design cast-iron parts to withstand vibration or alternating stresses will be interested to know that a series of Wöhler fatigue tests have recently been taken[5] on cast iron, and show that the material has a well-defined endurance limit. The stress at which the metal will stand an infinite number of reversals is defined without much scatter. The ratio of the endurance limit to ultimate tensile strength, that is the endurance ratio, is 0.35 and compares favourably with 0.5 for wrought iron and 0.42 for steel castings. Cast iron also responds admirably to understressing, and the endurance limit of samples was

[5] University of Illinois, Bulletin No. 164, 1927, by Moore' Lyon and Inglis.

raised 30 per cent. to 40 per cent. by this procedure, a surprising figure for a brittle material. The influence of holes, sharp corners and other stress raisers was also surprisingly small. The proportional diminution of fatigue strength at temperatures up to 400 deg. C., was less than the proportional diminution in tensile strength, which in itself is very small in cast iron. These results show that cast iron is much better in fatigue than might have been anticipated.

Brinell Test and Test Ratios.

Engineers and founders frequently ask whether there is a simple relationship between hardness of cast iron, such as measured by the Brinell test, and tensile strength. At present there is no means of converting Brinell hardness either into machinability hardness or abrasive wear hardness or tensile strength. Fig. 13 represents relationships which have been published for particular types of irons, chiefly on the Continent, between Brinell hardness and tensile strength. The caution with which these ratios have to be regarded is also well illustrated by Fig. 14, which shows relationships between tensile strength and shear strength published during the past few years. Any one relation is true for the irons experimented with, but it has no general application.

The Influence on Design.

Curves showing change of strength with section should be of assistance to designers, and although it may be argued that bars are not castings, it will be obvious that the differences between strengths of bars as cast are greater than between bars cut from different sections of castings because of the exchange of heat between them, the thin sections cooling more slowly and the thick sections more quickly than when separately cast.

The preparation of a size-strength curve to act as a basis for foundry production has the advantage that the occasional testing of one or two bars of different sizes during the day, enables a check to be kept on quality. It also enables the influence of experimental changes like alloy additions, changes in charge or coke, steel additions, cold blast additions and so on, to be ascertained, although again it must be remembered that strength tests do not measure all the properties demanded of cast iron.

Incidentally, the testing of a group of bars of varied sizes offers advantages over the testing of a single bar, which may be defective. With a group of bars the regular nature of the change enables bars of low strength to be picked out.

Conclusion.

The following conclusions may be drawn:—

1. Within the grey range of cast iron there is a continuous increase in strength as cast section diminishes, for tensile, compressive, torsion and transverse tests. The nature of the curve of change depends upon composition and other factors.

2. When the results obtained from the transverse test are properly interpreted by working out transverse rupture stresses, there is a relationship between tensile and transverse tests. For separately cast round bars the ratio may be taken as 1.8 to 2 for $\frac{\text{Transverse}}{\text{Tensile}}$ and as 4 for $\frac{\text{Compression.}}{\text{Tensile}}$ Ratios between other tests should be used with caution until the tests are standardised.

3. The change in strength with section can conveniently be followed by testing bars in transverse of different diameters from the same melt.

4. If a series of size-strength curves are prepared for different mixtures, it becomes possible to chart the connection between strength and those elements of composition which usually vary as between different mixtures in the same foundry.

5. Further development on the above lines in foundries working on their own mixtures is likely to provide useful information for the designer.

The author is indebted to the Council of the British Cast Iron Research Association for permission to publish this Paper, and to various members of the Association for providing test bars, the results of which are treated in the Paper.

W. Melle* tested thirty-eight high-quality cast irons and calculated the relationships between the different properties and the Brinell hardness number. He found the following results.

The relationship between the tensile strength and the hardness is given by the equation:

$$\text{Tensile Strength} = \frac{H - 100}{4} \text{ kg/mm}^2$$

H = Brinell hardness number.

The equation is correct for a hardness number of from 155 to 240. The curve representing this relationship lies between that given by Portevin, Schüz, and Thomas.

For the transverse strength and the compression strength Melle found the following equations:

Transverse Strength $= H \times 0.385 - 31$ kg/mm² and
Compression Strength $= \frac{3}{4} \times H - 56$ kg/mm²

The machinability was examined by the drill test according to Kessner. This method was described in a former issue of THE FOUNDRY TRADE JOURNAL.† Melle found the following equation:

$$B \times H^{1.47} = \text{constant} = 10{,}000$$

B = machinability = length of abscissa of the drill test diagram in centimetres = 5.5 × depth of the hole drilled by 100 revolutions of the drill. The equation is correct for the hardness numbers of from 90 to 300.

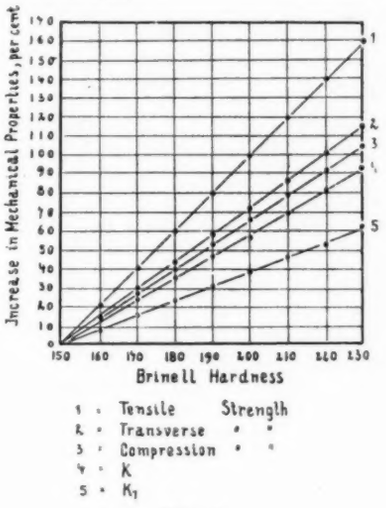


FIG. 1.

By increasing the mechanical properties of cast iron its machinability is decreased. It is important to know whether the improvement of cast iron be limited, that is, whether the gain in strength be compensated by high machining costs. The resistance encountered by the tool in machining is

W = q × k kilograms
q = cross section of the chip in mm².

The material number k is not constant, it is connected with the cross section of the chip by the following equation:

$$k = \frac{k_1}{\sqrt[4]{q}}$$

where k_1 is the material number for the cross section of 1 mm.² With the aid of the conditions existing in the drill test and the relationship between the machinability and the Brinell hardness given above, Melle calculated the following equations, giving the relationships between k and k_1 and the hardness:

$$k = 0.05 \times H^{1.47}$$
$$k_1 = 0.3 \times H^{1.11}.$$

Now all the properties of cast iron can be expressed by the hardness, and therefore it is possible to compare the increase of them to one another. This is done in the following figure, starting from a Brinell number of 150. It can be seen that the increase in strength is by far greater than that of k and k_1, which control the machining costs.

* Giesserei-Zeitung, 1928. No. 19. pp. 557-567; No. 20 pp. 596-602.
† FOUNDRY TRADE JOURNAL, Dec. 15, 1927.

Cast Steel Cable Made in South Wales.

In July, 1928, the Admiralty placed an order with the best known British steel foundries for one experimental length, *i.e.*, 12½ fathoms of 2⅜-in. cast-steel link chain. The first firm to complete the order was Messrs. Brown, Lenox & Company, Limited, of Pontypridd. This firm was also the first to make wrought iron cable as far back as 1803, since which date they have supplied the British Admiralty and foreign Governments constantly. The sample length was tested, and gave entire satisfaction to the Admiralty. The specification of the steel chain and also the same size W.I. chain were as follows:—

	Steel. (Weldless).	W.I. (Welded).
Proof test	130 tons	101½ tons
Min. breaking test required on 3-link sample cut from chain ...	195 tons	152¼ tons

The actual breaking load given by the 3-link sample selected by the Admiralty was 232.1 tons, *i.e.*, 78.5 per cent. above the required proof test. The elongation at proof had not to exceed ¾ in., and the elongation was 11/16 in.

A further test—which had never been applied to any 2⅜-in. before—was required. Two links were cut out from the completed length and these were submitted to a shock test in such a manner that the link was in tension and not in compression, as is usual in dropping tests. The specification called for the following:—

Blows from a 15-cwt. Falling Weight.
2 at 10 ft. drop.
2 at 15 ft. drop.
6 at 20 ft. drop.

Both links selected withstood these tests without a sign of fracture, and in an endeavour to fracture one link a further series of six blows at 20 ft. drop were given (making 12 in all at this height). The link was still without sign of fracture, but had elongated 2 ins.

The steel used was made in a 2-ton Heroult electric furnace, and has the following properties:—Tensile stress, 35 tons per in.; yield point, 23 tons per in.; elongation, 25 to 30 per cent.; and bend test over 1 in. dia., 135 to 180 degs.

The method of moulding allows for machine-moulding methods to be used throughout. The foundry manager employed at this works has applied for patent rights for his process. A further achievement of Messrs. Brown, Lenox is that they have manufactured a 20-fathom length of ordinary 1¾-in. open-link chain, which gave similar results, since when it has given every satisfaction in service where wrought iron had failed due to excessive corrosion.

Leicester's Outlook.

With regard to the future, the signs in the foundry and engineering trade of Leicester are more encouraging. Manufacturers of machine tools are busier than was the case a month or so ago, and this is an indication that manufacturers of all kinds of goods have confidence in the future to the extent that they are prepared to lay down new tools of various kinds. As a rule, trade is quiet after the holidays, but this year the quiet period seems to be extending rather longer than usual. In spite of this, however, the engineering trade is reported to be fairly good, and it is anticipated with every confidence that in the near future orders will come in much more freely. The electrical engineering section and manufacturers of lifting tackle continue to be quite busy.

Inquiries also show that there are a number of requests for tenders for the supply of machinery and the like for foreign countries and in the hands of the British Board of Trade.

Symposium on Steel Castings.

CLOSING DISCUSSION.

(*Continued from page 56.*)

MR. FRANK HUDSON said that the experience of Glenfield and Kennedy with steel castings, in hydraulic engineering, was not altogether a happy one, especially in light valve castings having relatively thin sections. On the other hand we had little to complain about in the heavier work, and quite recently some 54-in. valves went through the shops without any defects in the castings coming to light during machining operations or under hydraulic test. In light valve castings, however, they usually returned at least 50 per cent. of the castings received to the foundryman as scrap or for some attention, such as welding, etc.

He drew attention to Fig. A, which gave a sectional drawing of a 3-in. cast-steel valve, and typical of the general run of light castings. The greatest number of defects existed as porosity in the top flange which one soon found out when drilling flange bolt holes, followed by blow- or sand-holes on the valve faces, and lastly hard spots on the valve faces. Mr. Jefferson suggested that it would be very helpful for the steel founder, when castings were found defective by the customer, to have the correct information as to the actual cause of the defect rather than the general term "blowholes." This information to be of any value must of necessity be determined by those responsible for the manufacture of the casting. At the same time he would like to see all foundries make a better analysis of defective castings. Admittedly they can all say what the percentage of defective castings was for the last financial year, but how many could say that out of this percentage they had had so many defective to shrinkage cavities, so many defective to hot-tears, etc.

From personal knowledge of one firm who kept careful statistics they now found that their greatest machine-shop-rejects were due to shrinkage holes, followed by dirt and slag inclusions, then hot-cracks. The actual percentage of bad castings due to shrinkholes was 36 per cent. of total machine-shop rejects. This confirmed Dr. McCance's remarks, and at the same time gave added emphasis to the need of very intimate co-operation between the designer and founder. In this question of design uneven distribution of metal and improper filleting produced castings which were an eye-sore to the engineer.

The porosity found in the top flanges of the light steel valve shown in Fig. A was due to this. In the heavy valves, although the change of section was just as pronounced, his firm so far had not been bothered with porosity or shrinkholes, due to intelligent placing of suitable fillets as shown in Fig. B. The fillets shown at "a" and "b" proved unsatisfactory, whilst "c" was in general use for their heavy valves. "d" was the actual section of a 54-in. valve where the flanges join the body and show the fillet. No cavity had ever been found when drilling flange bolt holes. This, to his mind, showed the advantages to be gained by co-operation between the designer and founder. whilst at the same time it should be particularly noticed that in many cases this co-operation would result in the production of sound castings without a radical alteration of design.

Commander Sidgwick would no doubt be interested to learn that it would appear from his experience that the lighter or thinner the casting then the greater the number of rejects in the machine shops. He was more or less in agreement with the engineers' requirements, as outlined by Commander Sidgwick, but suggested that surface finish was also of importance for obtaining better steel castings. It seemed to him that mould surface played only a minor part in this matter, and the roughness of some steel castings was mainly due to the viscous nature of molten steel.

In conclusion he drew the engineer's attention to the price question. It would appear that it was not quite appreciated that, apart from the actual value of the founder's art, over 200 tons of material and tackle must be used and handled in the average steel foundry to produce one ton of castings. This could not be done for nothing, and no doubt left the steel founder very little surplus to play with.

Elastic and Plastic Strains.

MR. G. F. GILLOTT, B.Met., said that for the past year he had been engaged in research work on steel castings at the Research Department, Woolwich. Dr. Pullin had given an illuminating account of X-ray methods applied to the examination of steel castings. A great advantage of this system was of course that it was rapid, accurate, and did not injure the castings. As Dr. Pullin had explained, interpretation of the X-radiographs requires considerable experience. As a rule, cracks, excepting the finest, were fairly readily identified, but with cavities some difficulty occurred. The radiologist usually described these as "blowholes." For many purposes such a general description was quite adequate, but to the metallurgist, a more exact knowledge of the nature of these voids was essential. At present it was necessary for this purpose to supplement the indications of the X-radiographs by a critical metallurgical examination of the sectioned casting. This unfortunately meant destroying the casting and took some time.

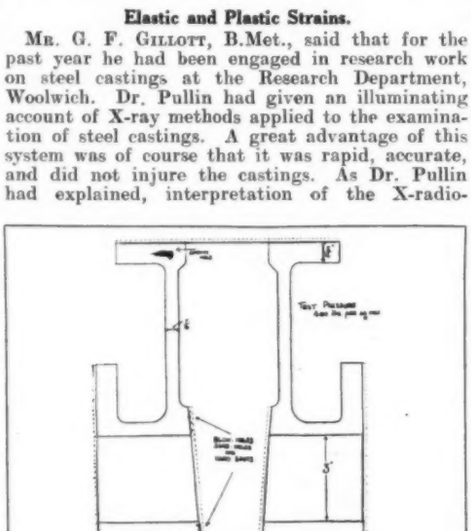


FIG. A.

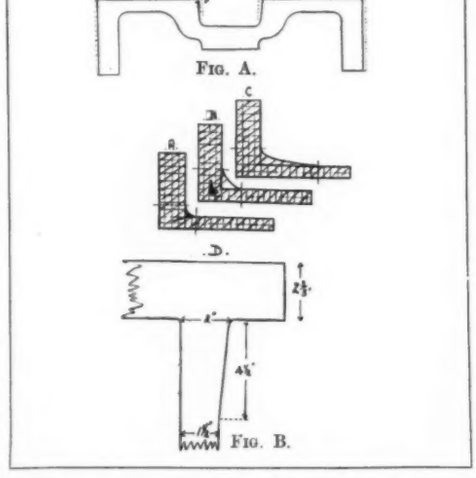


FIG. B.

Another point worthy of mention in connection with X-ray examination was the question of strain in castings. If this was "plastic" it was harmless, provided that it had not been so great as to develop flaws in the metal. If, however, it was "elastic," this implied the existence of stresses in various parts of the casting, balancing each other, and possibly concentrated in some of the angular sections. These "elastic" strains might be serious since they may be stressing the casting in the direction in which it will be stressed in service and so diminishing the factor of safety. It would be of great assistance if radiologists could discriminate between strain accompanied by stress (*i.e.*, "elastic" strain) and strain with no remanent stress (*i.e.*, "plastic" strain).

He thanked Dr. McCance for drawing attention to the loose use of the term "blowhole." Blowholes caused by gases evolved by the metal could generally be put down to steel of poor quality or insufficiently deoxidised, a comparatively rare complaint in the modern steel foundry. This point deserved mention in view of the fact that some research workers had described gases in steel as a "casting defect." It is rather a "steel-making" defect. The majority of serious voids were not blowholes, but shrinkage cavities. These could usually be avoided by casting with the heavier sections uppermost and by providing large feeding heads over the heavy sections. Unfortunately, as Mr. Jefferson had pointed out, the additional expense necessary to ensure soundness was considerable, and on that account many foundries were obliged to take the risk of "draws."

Strength of Elevated Temperatures.

However, these, and other defects, were of a comparatively minor nature compared with cracks. These were of a most persistent nature, and difficult to repair satisfactorily. Most cracks might be described as "pulls" or "hot tears." As the steel was cooling down from the molten state, the contraction stresses were gradually increasing in magnitude. At the same time the steel was coming stronger, so that the matter resolved itself into a race between the two factors. There were two possible methods of attacking the problem: First, by reducing or releasing the stresses before they become dangerous, and second, by increasing the strength of the steel at high temperatures, as for example, by careful attention to its purity, or by the use of alloying elements such as nickel or chromium. The latter method also had the effect of greatly improving the mechanical properties of the finished castings. No doubt much remained to be investigated in the way of providing moulds and cores which yielded readily on the cooling of the metal, but which possessed the initial mechanical strength and refractoriness to withstand the pressure and erosion of the molten steel. To eliminate the hot-tear, some means must be found to decrease the contraction stress, or increase the strength (or both), so that at any temperature during cooling the steel has adequate strength and ductility to deal with the stress which was being imposed on it.

In conclusion he remarked that his thanks were due to Dr. R. H. Greaves, of the Research Department. Woolwich, for permission to take part in the discussion.

MR. JACK CURRIE said that as a foundryman, his remarks were necessarily directed towards the author of the first Paper. It was rather a difficult matter to criticise, as Commander Sidgwick had clearly stated what he wanted, and surely if he was prepared to pay for it he would get it, if it was at all possible; but he himself was rather afraid that in a few isolated cases it was the impossible Commander Sidgwick had demanded. It was rather disconcerting to the steel-founder to hear from the authorised representative of the Admiralty that the quality of British steel castings was not quite up to the high standard required.

Dr. McCance and Mr. Jefferson both came to the common conclusion that more co-operation must exist between designer and founder, and Mr. Currie suggested one line of thought that such co-operation might follow. In cases where intricate castings were required, difficult to mould and feed properly and the only beneficial property seemed to be one of cost, he thought that the idea of making a composite casting should be considered. By composite, he meant the making of the casting in two or more pieces and building up to produce the finished article. In many cases this might not be possible, but in some it would be quite feasible, and although increased cost might be incurred, increased quality would certainly be the result.

Commander Sidgwick did not mention much in his Paper regarding alloy-steel castings, and to his mind such castings represented the answer to the engineer's demand for steel of improved qualify, as by the proper application of alloying elements it was possible to obtain increased physical properties. Alloy steel, however, could not be considered a panacea for all the troubles that arise in the use of steel castings, and owing to the difficulties in manufacture and increased service such castings necessarily demanded a higher price than was asked for ordinary steel castings.

Unification of Standards Desirable.

Mr. Currie, continuing, said that much trouble and expense would be avoided if there was a co-ordination of specifications, as at present it seemed to the founder, at least, ridiculous that two castings of the same pattern for the same purpose should be made to entirely different specifications, thus causing increased trouble to the manufacturer with no increased service to the user. This might seem a minor point, but if a foundry had to cater in the same day for material to meet specifications such as 26/32, 28/32, 30/37, 35/40 and 38 tons min. per sq. in., the trouble entailed could be partly realised. Surely a standard steel of, say, 34/36 tons per sq. in., with a minimum elongation of 15 per cent., would meet the case for all purposes, and at the same time make it possible to cast intricate castings, which when required in the softer qualities of steel were almost impossible to produce without flaws appearing in some place or other.

He would also have liked to have heard Commander Sidgwick pass an opinion on the quality of castings obtained from the various processes by which steel castings were now commonly made, or at least the three mentioned by Dr. McCance, namely, the electric, acid open-hearth and converter. He understood that whilst the Admiralty were prepared to accept general castings from any of these processes, they would not allow the converter process to be used in the production of castings which had to withstand fluid pressure. This was rather difficult to understand, as by taking proper precautions steel could be produced by the converter process capable of complying with any test requirement. It was fluid enough to run the thinnest types of castings, and whilst the impurities, as shown by Dr. McCance, were as a rule higher than in the other two processes, this had the advantage of nullifying to a certain extent the evil effect of fluid contraction, although it had to be admitted at the same time increasing the tendency of the material to develop flaws during solid contraction. The only point to his mind which might rule out the converter process was that the human element entered into it to a greater extent than was the case in either the electric or open-hearth furnaces, but he did not think that this, in face of the results obtained by this type of furnace, should debar a steel-founder from manufacturing material which was well within his scope. Regarding the limit of thinness asked for, this is rather a difficult and dangerous question to answer, as thinness could only be taken in conjunction with something else, and must be relative to the size and shape of the casting desired. Mr. Currie said that he had diverged in some of his points from the actual Paper, but as they were things in which he was very interested, he would like to hear Commander Sidgwick's opinion on these matters.

Limitations in Co-operative Activities.

MR. WALTER WEST (Leyland) said that it was well to recognise that there were limitations which beset the designer as well as the foundryman, a fact that accentuated the great need for a closer working between the two. The designer, of the desirable type of mind, was only too anxious to assist when the anticipated difficulties created by the design had been pointed out. In like manner, it was also essential that the patternmaker should also join in the discussion. Co-operative effort on a large scale would be of immense value to investigate many phenomena which affected the broad principles of steel founding, but something deeper than any work which a national body of research workers could effect was urgently needed. In the first place, it would not be possible for a national association to look into with precision, problems which arose with every differing pattern. Here, was called for that personal initiative from the foundry management which would take him to the user, after very careful consideration of the work to be carried out, and boldly state any difficulties which presented themselves. A man inspired with such enthusiasm would strike the right note for a frank, amicable discussion with the most conservative of designers. This method of attack would produce direct results, which no national effort could possibly accomplish, and it would be an assembly of such individuals, who, being in immediate touch with the needs of the Admiralty or the engineering trade in general, could advise and direct the activities of the proposed association without unnecessary loss of time or money.

It was misleading for foundries to put their entire hope in such an association, and in their own circle of activity they, themselves, should therefore display a similar spirit of co-operation with their customers.

Assuming that every step had been taken to produce a design to the satisfaction of designer and founder, and that such had been correctly interpreted by the patternmaker to give the easiest and most effectual method of production from the view of coring up the mould, immediate release of the casting after pouring, and commercial profit, the result then depended to a large extent upon the foundry technique. That such was not simply confined to the moulder was easily proved. Solidity or homogeneity of a casting—having already assumed that the question of design was settled—depended primarily upon the disposition and size of feeding heads. Other factors, such as the method of running and the size of the runners, had a great influence over the results, but the fluid pressure exerted by an ample number of liquid-steel reservoirs could not be replaced by any of the expedients which were so often adopted in the foundry. Further to this, in spite of much excellent research attention which the manufacturer of steel had been given, it had to be admitted that this work had been directed more towards the making of steel ingots than steel for castings. There was much yet to learn, and for a national association to take up such a question would be of great assistance.

Properties of Electric Steel.

Broadly speaking, there were three processes of manufacture—open-hearth, the converter and the electrical furnace, each of which would produce steel of identical chemical composition, but with what difference in physical behaviour during solidification, only those who had a wide experience or had worked the three methods could describe. That steel had certain definite physical properties which founders could not alter was correct as a broad statement, but, for example, in the electric furnace, where unlimited amount of heat energy was available, a condition which, on the face of matters would appear to be admirable for the production of thin section castings. The truth, however, was that this flexibility of operation was a source of danger in disguise, for steel produced with degrees of super-heat, changed in its physical behaviour during the period of solidification. Experience showed, without the theoretical explanation to give the reason, that such steel has inherent tearing or cracking properties, and no matter to what temperature the metal might be cooled the same phenomenon was observed. This was sufficient evidence to the practical mind that the thickness of the section was not only limited by the possibility of running the metal to every extremity of the mould, but also by the degree of super-heat which could be given to the molten steel. Furthermore, they, as founders, had not exploited all the possibilities in the manufacture of steel for high-pressure steam castings. The physical characteristics of molten steel were not entirely derived from the chemical composition, but could be affected by the manner in which the molten bath was treated during the refining period. Experiments had shown that by an unusual method of "killing" or finishing the metal—a difference in the behaviour and consistency could be obtained. While definite information could not, as yet, be given with sufficient surety for general broadcast, the following test results obtained would indicate that the steel differs sufficiently from the usual as to warrant the conclusion that further knowledge could still be obtained from research on these lines:—

	C. P. cent.	Y.P. Tons.	M.S. Tons.	E. P. cent.	R.A. P. cent.	Brinell No.
A8073	0.30	28.5	40.4	22.5	31.5	170
A8093	0.27	27.3	41.0	21.5	30.0	187
A8079	0.26	28.4	39.8	23.5	38.5	170

Ignoring the test results here given, the cream-like appearance of the steel made in this manner at the normal temperature of casting in foundry practice, called for distinct notice. The behaviour also during solidification in the mould more than indicated that the shrinkage, if as great as the usual run of steel of similar composition, the liquid metal had a life sufficiently long well to cater for it.

Oil-Sand Cores and Hot Cracks.

The extensive use of brackets in foundries to prevent cracks occurring in steel castings indicated that sufficient attention was not paid to the material used in the making of the internal sand cores. Here, consideration could well be given to the use of oil-sand cores in place of those made in naturally-bonded sand. Limitations accompany such a suggestion, in view of weight and size of the casting required, but there was little doubt now left in the minds of those manufacturers who had adopted such mixtures, that hot cracks were thereby greatly reduced in number.

In conclusion, Mr. West said that the suggestion regarding an advisory committee, composed of engineers and foundrymen, for the purpose of discussing the question of steel castings, was greatly to be recommended, and was anxiously awaited by progressive members.

Pointers in Relation to Competition.

MR. D. SHARPE thought for the type of castings being discussed there were two types of steel founders—one good and one bad. The bad steel founder who turned out steel castings with the main aim of profits should not give consideration to the manufacture of the high-duty castings called for under discussion, but should leave them to the steel founder who could be classed as good for this type of work. The so-called bad steel founder might be quite competent to deal with the class of casting which was his normal product, probably better and cheaper than the man making the good quality of steel casting. Occasionally, however, whilst passing through periods of dull trade the lower grade founder was tempted to venture into the high-quality market, send in a quotation which was so attractive to the buyer that he jumped at it. The net result was trouble all round. He was putting forward this point of view in the belief that it would be helpful to the discussion.

One other point he brought forward was in regard to thin section steel castings. He had dealt with in his experience a very wide range of thin sections, in this country, in Belgium, and in the United States, and he believed that the real difference between these competitors and the average British firm was the process, the Belgian and German makers producing a green-sand casting while British founders still remained firm for a dry-sand casting. They were, however, gradually developing the green-sand casting, and of the good steel founders here many were able to get green-sand castings equal to those produced on the Continent. With regard to a remark made about the electric furnace, this was limited to the smaller marine-engine casting, and could not in its present stage deal with large hull castings.

A great part of the discussion was related to what might be called pipe-line work, high-pressure and high-service castings. The electric furnace had a great advantage in producing such castings. Defects in steel castings had been enlarged upon, but he thought it would be very helpful to a future discussion of the same kind if the engineers, on the other hand, would make a careful tabulation of the defects occurring at their plants, and make a list of headings, including blow holes, slag, and sand inclusions, tears and draws, and support that with a percentage scale

with which to shock the steel founder. He was able to trace in his own experience of about 25 years in steel founding the improvement that had been made in steel castings over that period, and he believed that if the average engineer nowadays was to secure a casting like the average sent out 25 years ago there would be a revolution. The improvement has been going on steadily from year to year, and he thought that from a good steel founder one could obtain high-grade castings of any reasonable design.

Inarticulate Founders Create Trouble.

DR. J. W. DONALDSON wrote:—The four Papers on steel castings were of considerable importance and demonstrated the difficulties of steel founding. Engineer-Commander Sidgwick had given quite definitely the Admiralty requirements for steel castings, and then put forward four possible reasons why those requirements were not being met.

As regards the first of these, whether the designer was asking too much of the founder, the designer, as a rule, only asked what the founder stated he was quite prepared to give. If the designer asked too much the founder should refuse to attempt those designs, and the designer would be forced to meet the founders' requirements. Founders seldom did this, and the designers' conclusion was that moulders did not know till they tried whether a particular design could be cast successfully or otherwise. If the moulders did not know it could not be expected that the designers should know.

It was agreed that there were frequently designs that could be simplified or improved, and it was equally true that the suggestions of founders would be met, if at all possible, but the time for this was before castings were attempted. There were designs, however, so intricate that the founders should refuse to make them in cast steel, and engineers should be asked to accept them in cast iron, and would find them more satisfactory, especially if the higher grades of cast irons now available were adopted.

Regarding the second and third reasons, the standard of soundness set by the Admiralty was one with which engineers generally would agree, as the standard must necessarily be high, if such castings were to serve their engineering purpose. While Dr. McCance and Mr. Jefferson's Papers showed that some founders at least had done their best to perfect the art of steel founding, Dr. McCance's Paper, in the first instance, left an impression that the difficulties of steel founding were so very great that success can only be achieved in the simplest castings. Mr. Jefferson's Paper was, however, a complementary one and corrected such an impression to some extent, but it was hoped that founders would supply facts to remove this impression altogether.

The fourth reason that steel castings were already up to the required standard would not be endorsed by users in general. The percentage of defective castings passing through the average engineering works was still too high to give confidence, and many engineers looked with the greatest suspicion on steel castings, and this suspicion should be allayed as much as possible. Commander Sidgwick depreciated the patching of unsound castings, and he (Dr. Donaldson) agreed with him, as welding was not only a palliative, but was too often used to cover up defects, which, if seen in the first instance by the user would lead to the immediate rejection of the casting.

Dr. Pullin's Paper on the X-ray examination of steel castings opened up a new field of testing of considerable interest to the metallurgist, and gave an insight into the possibilities of this method of testing for castings of all types and materials. His remarks about crystal analysis and strain removal were extremely interesting, and, when developed, would form a very valuable addition to the present mechanical and metallographic methods of testing for satisfactory annealing.

In dealing with cooling conditions Dr. McCance stated that in castings of complicated design the usual pattern allowance of 1.6 per cent. contraction disappears. Did he mean that the pattern-maker could not make such an allowance owing to design, or that the allowance was made but could not be taken advantage of owing to the physical conditions of the molten metal when cooling?

Quality and Price Considerations.

Mr. Jefferson stated that satisfactory steel castings could be made, but at prices which he indicated may be higher than those generally quoted. If that was so, why was it that satisfactory castings can be obtained from foreign sources and at prices averaging 40 per cent. less than those obtained at home. A recent example which came to his (Dr. Donaldson's) notice was of a cast steel stern frame where the Continental price was one-third of the lowest British price—that is, 66 per cent. less—and where a sound and satisfactory casting was supplied at this price.

It was also stated by Dr. McCance and Mr. Jefferson that if the design of castings were improved more satisfactory castings would result, and general agreement would be expressed in a larger amount of real co-operation between the designer and the founder. One felt, however, that in addition to the four Papers read a fifth one from the designer's point of view was necessary to complete the series.

Definite Improvement in Technique Recorded.

MR. ROBERT SCOTT wrote:—Commander Sidgwick's Paper introduced such a vast field for discussion that it appeared to him the best way would be to attempt to discuss the one or two special points which particularly interested him or applied to any special knowledge of the trade. (1) The designer asked too much of the founder, and (2) that the founder had not fully explored the possibilities of his art. The founder was unable to say whether he could meet the design or not without actually attempting to produce the casting called for. This was the only way at present that the founder had of furthering his research work and advancing his technique. He had also the spur behind him to attempt those new designs by the knowledge that if he did not his competitors would. Speaking of founders' experiences, they were daily producing castings which six or seven years ago they would have refused as being impossible to make, and they felt that they were improving their technique every month. They could assure Commander Sidgwick that they are not standing still, but were using every effort to improve their productions.

The *soundness* insisted upon by the Admiralty must necessarily be high, but small defects in the casting, which did not affect strength and utility of casting, should receive reasonable consideration, as no one could expect perfection, and especially 100 per cent. perfection.

As regards *minimum thickness*, it was thought that the present sections asked for were the minimum, and in some cases under it (considering the number of foundry rejections), but no doubt any steel founder would undertake to attempt much thinner sections for the Admiralty on a time and line basis. In the present financial position it was almost impossible for any steel founder to undertake research work for the Admiralty unless on such a basis, as, after all, a steel foundry was a commercial undertaking.

With regard to Dr. McCance's and Mr. Jefferson's Papers, being confrères, the majority of these contentions is naturally agreed with, and especially with one remark by Mr. Jefferson that the Admiralty need not expect good steel castings to be cheap.

Contracts Open.

Melbourne, February 5.—Cast-iron cable boxes, for the Ports and Telegraphs Department. The Department of Overseas Trade. (Reference B.X. 5029.)

Pudsey, January 22.—260 yds. of 4-in. water pipes, spigot and socket, coated, also 1,032 yds. of 3-in. water pipes, for the Town Council. Mr. A. E. Evans, town clerk, Town Hall, Pudsey.

Rothbury, Northumberland, February 9.—Cast-iron or steel water mains, for the Tynemouth Corporation. Mr. J. W. McKerrow, water engineer and manager, Norfolk Street, North Shields. (Fee £1 1s., returnable.)

The Bellfounding Industry.

During the past year Messrs. John Taylor & Company, the well-known bellfounders, of Loughborough, have been quite busy, and prospects for 1929 are as healthy as those of 1928. It will probably be surprising to many to know that at the present time carillons manufactured in Loughborough ring all over the world.

Last year their shops made and installed four great carillons—one for the University of Sydney, New South Wales, Australia, and three for the United States of America—in addition to many new bells and restorations completed for churches and public buildings throughout the British Isles.

In a bird sanctuary at Mountain Lake, Florida, a carillon of sixty-one bells was installed, the largest bell weighing 10¼ tons, this carillon representing the greatest weight of bells ever assembled together at one time for one order by any firm of bellfounders in the world. With all these installations the Taylor electro-pneumatic playing apparatus has been fitted, by means of which the carillon may be played through the instrumentality of perforated paper rolls on the principle of a "pianola." An alternative method of playing these carillons is from an ivory keyboard, similar to that of any organ or piano.

At one period during the year Messrs. John Taylor & Company were engaged on work for six British cathedrals—namely, Lincoln Cathedral, where they augmented the peal to one of twelve bells by the addition of four new trebles; Newcastle Cathedral, where they have re-hung the peal with modern fittings; St. Paul's Cathedral, London, where they overhauled the peal of twelve bells; Worcester Cathedral, for which they made a fine new peal of fifteen bells and re-tuned the Bowdon bell, and at Johannesburg and Pretoria Cathedrals.

During the course of the year they carried out augmentations, restorations, etc., of peals in almost every county in England. They founded the clock bells which are installed in the new Exchange Buildings, Nottingham. The largest of these bells, upon which the hours will be struck, weighs nearly 10½ tons, and is of very fine tone indeed. Messrs. Taylor & Company are looking forward to the New Year confident of a continuation of the prosperity they have hitherto enjoyed as one of the world's leading bellfounders.

The Lead Industry.

Mr. H. C. Lancaster gave an interesting review of the lead industry at a meeting of the London Local Section of the Institute of Metals, held in the Rooms of the Society of Motor Manufacturers and Traders, Limited, on Thursday, January 10. Dr. S. W. Smith presided over a good attendance.

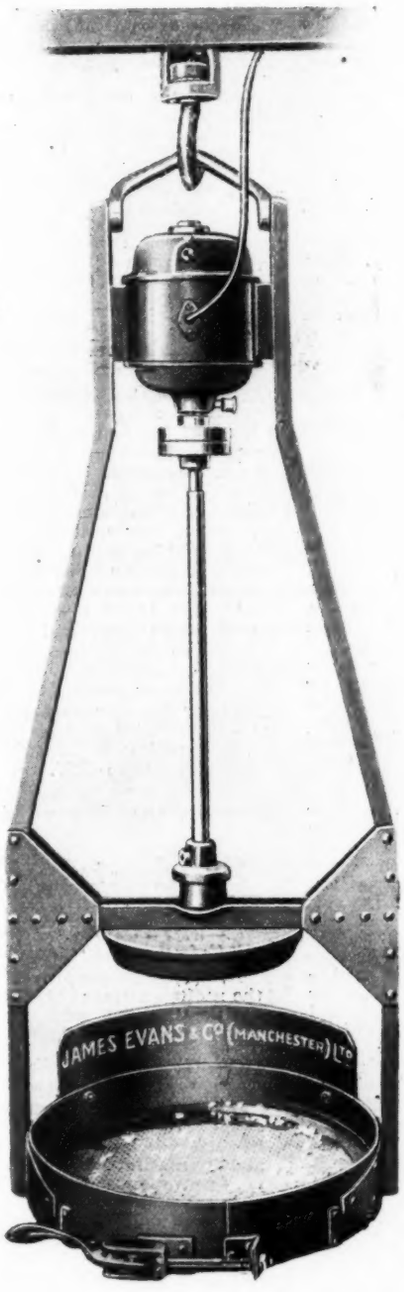
The lecturer showed numerous interesting lantern slides describing the different manufacturing processes in the lead industry. A view of a section of one of the original roasting furnaces used for the smelting of lead ore was followed by a diagram of a lead blast-furnace designed by the author himself. The manufacture of lead pipes was fully described, photographs being shown to illustrate the various stages of the process. The author also dealt with the manufacture of lead shot, then passing on to the manufacture of lead oxide.

The process of the extraction of silver from the lead was also touched upon.

Iron and Steel Institute Autumn Meeting.

It will be recalled that at the Autumn Meeting of the Iron and Steel Institute at Bilbao, last year, Prof. Henry Louis, M.A., D.Sc., was unanimously nominated for election as the next President of the Institute, and he will take office at the Annual Meeting in London on May 2, 1929. Prof. Louis being a prominent citizen of Newcastle-upon-Tyne, the members resident in that neighbourhood considered that it would be very appropriate to hold the Autumn Meeting in that city during Prof. Louis's Presidency. The Lord Mayor and Corporation of the City of Newcastle-upon-Tyne have sent a cordial invitation to the Council of the Institute to hold the meeting there, and the date has been fixed for September 10 to 12, 1929.

EVANS'S ELECTRIC
GYRATORY FOUNDRY RIDDLE



THE saving accomplished by the use of our Electric Gyratory Riddle pays for the cost of the machine in a few weeks' time.

It will sift more sand with one operator than six men sifting by hand. In addition to this it mixes the sand better, and produces a better grade than hand labour.

The machine is portable and may be moved to any place in a few moments (where a hook for suspension is available and electric current in service) and set in motion instantly.

Motor and working parts are all above the sieve, thus preventing the sand from interfering with the operation of the machine.

Power required, ½ B.H.P.

JAMES EVANS & CO. (M/c) LTD.

Britannia Works, BLACKFRIARS, MANCHESTER

Trade Talk.

SILICA GEL, LIMITED, have removed their offices from 23, Abbey House, Victoria Street, S.W.1, to Bush House, Aldwych, and their postal address is now Bush House (West Wing), Aldwych, London, W.C.2.

MESSRS. PALMERS SHIPBUILDING AND IRON COMPANY, LIMITED, Jarrow-on-Tyne, have booked an order from Messrs. Moss & Company, Liverpool, for a motorship of 10,000 tons, with engines to be supplied by the Wallsend Slipway and Engineering Company, Limited.

MESSRS. WILLIAM BEARDMORE & COMPANY, LIMITED, Dalmuir, have launched a tug named the "Northgate," which they have built for the Falmouth Dock and Engineering Company, Limited, for harbour services. She is the first tug to be fitted with Beardmore-Caprotti valve gear.

IN VIEW OF THE unemployment in the steel industry of this country, the Ayr Town Council have instructed the engineers of the Loch Recawr water scheme that in connection with the pipe line from Loch Finlas, tenders for Continental steel pipes should not be entertained, and that only offers to supply British manufactured pipes be considered.

BRITISH INSULATED CABLES, LIMITED, have received an order from the General Post Office for the laying of telephone cable between Preston and Blackpool. The distance is approximately 21 miles. This is the second cable that has been laid by this firm between these two points. They have also received an order for 16 miles of telephone cable for the Isle of Man.

THE EMPLOYEES of Messrs. Markham & Company, Limited, Broad Oaks Ironworks, Chesterfield, who hitherto have been paid wages 10 per cent. above the usual rate in the engineering industry, are to suffer the withdrawal of this concession, owing, it is stated, to the keen competition experienced in obtaining contracts. Wages last week-end were accordingly reduced by 2s. in the £.

THE WELLMAN SMITH OWEN ENGINEERING CORPORATION, LIMITED, Victoria Station House, Victoria Street, London, S.W.1, have recently obtained the following contracts:—One Wellman tilting furnace of 100 tons capacity, and one 150-ton ladle crane, for the Alfred Hickman branch of Messrs. Stewarts & Lloyds, Limited; one bloom-charging machine and one 20-ton crane, for the Earl of Dudley's Round Oak Works, Limited; one continuous tyre-bloom heating furnace and one 10-ton crane, for Taylor Bros. & Company, Limited, Manchester; one heating furnace, with bloom-charging machine, and one grab crane, for the Partington Steel and Iron Company, Limited; and one 5-ton open-hearth charging machine, for the Australian Iron and Steel Company, Limited, Port Kembla.

IN ACCORDANCE with Stock Exchange regulations, particulars were advertised last week, for information only, of the N.C. Metal Company, Limited, which has an authorised capital of £250,000 divided into 230,000 "A" ordinary shares and 20,000 "B" ordinary shares, all of £1 denomination. Of the "A" shares, 200,000 have been issued, and the whole of the "B" ordinary shares have been issued for cash at par, and are fully paid, to Messrs. Stewarts & Lloyds, Limited, in order to ensure control of the company. The company was incorporated to acquire from H. Edwin Coley, Limited, the rights in an invention for the extraction of zinc from ores. A plant owned by a licencee has been in operation for a considerable time, and, it is stated, has proved that the process is capable not only of giving a higher extraction of zinc than has been previously obtained, but of securing that extraction at a much decreased cost.

THE RATING ASSESSMENTS on two Sheffield steel firms, Messrs. Cammell Laird & Company, Limited, and Messrs. John Brown & Company, Limited, were reduced in each case from £27,000 to £25,000 as a result of an appeal at the Sheffield Quarter Sessions on January 11. Counsel stated that the assessments of Messrs. Cammell Laird's works had gradually increased till at one point the figure was put at over £40,000. In the present instance objection had been made to £30,609, and the Assessment Committee had reduced it to £27,000. It was against the latter figure that appeal was now being made. The firm's Cyclops Works specialised in armour plating, and had been run since 1921 at a very substantial loss. Through no fault of the firm, there was no demand for the products of the works. In an endeavour to keep the works going, substantial sums had been expended in putting up a foundry, in the hope of working it at such a profit as to make up for the losses on the armour plate. Unfortunately, that had proved impossible, and the foundry had been run at a loss. The Recorder reduced the assessment by £2,000, and made a similar order in the case of Messrs. John Brown & Company, Limited, whose appeal was not gone into, counsel on both sides arriving at agreement on that amount.

Personal.

MR. A. MCA. TENNANT, who has been metallurgist for some years with Messrs. Renton & Fisher, Limited, Bathgate, has left to take a similar position with Wolseley Motors, Birmingham.

MR. J. H. WADSWORTH, who has been secretary of Imperial Chemical Industries, Limited, since its incorporation, has been elected to the board of the company, and to its executive committee.

MR. L. H. HINES, formerly sales representative for Messrs. Pneumatic Engineering Appliances Company, Limited, has now been appointed manager of their works at Derby Street, Cheetham, Manchester.

MR. WILLIAM BELL, who for a number of years has been foundry manager at Messrs. William Beardmore & Company, Limited, Speedwell Works, Mossend, has left to take up a similar position in Whitehaven.

MR. JOHN R. HOPE, who was formerly with Messrs. Sir W. G. Armstrong, Whitworth & Company, Limited, has joined the Partington Steel & Iron Company, Limited, Irlam, Manchester, as general sales manager.

MR. W. C. MCALLISTER, who left Messrs. Harland & Wolff, Clyde Foundry, about two years ago to become foreman at Barrow, has now returned to Scotland as foundry foreman to Messrs. A. & F. Craig, Limited, Paisley.

MR. MARK HURLL, on the occasion of his appointment as managing director of Messrs. P. & M. Hurll, Limited, fire-brick and gas-retort manufacturers, of Glenboig, was the recipient of a presentation from the workmen of the firm's Garnqueen and Garliston works.

Wills.

BURNELL, C. S., of Midvale Road, Paignton, ironfounder £23,082

DALGLEISH, A., boilermaker and ironfounder, Glasgow £7,279

RAINE, J. E., of Fawdon, Northumberland, managing director of Messrs. Raine & Company, Limited, iron and steel manufacturers, of Derwenthaugh, Gateshead £34,744

Obituary.

MR. ROBERT MORGAN, of the firm of France & Morgan, Limited, brassfounders, Govan, died at Dumbreck, Glasgow, on January 15, in his 90th year.

THE DEATH TOOK PLACE, on January 5, of Mr. James Chalmers, who was in his 70th year. He was for many years timekeeper at Messrs. Dobbie Forbes & Company, Limited, Larbert Foundry.

THE DEATH has taken place, at Bonnybridge, of Mr. George Wyse Reid, who for over fifty years was in the employ of Messrs. Smith & Wellstood, ironfounders, Bonnybridge. Mr. Reid had recently given notice of his intention to retire, but two days prior to the date fixed for his retiral he collapsed whilst sitting in his chair and never regained consciousness.

MR. FREDERICK ISIDOR SANDERSON, a director of the Wellman Smith Owen Engineering Corporation, Limited, whose death was recently announced, was a well-known figure in the steel trade, and had been connected with the Wellman Smith Owen Company over a period of 25 years. Mr. Sanderson's business career commenced when he joined the staff of the late Col. J. T. North, who had extensive nitrate interests in Chile. In 1904 he joined Messrs. Jeremiah Head & Son, who were at that time European agents of the Wellman-Seaver-Morgan Company, of Cleveland, Ohio. He also acted as secretary of the Otis Steel Company, Limited, of Cleveland, then controlled in England. In 1905 Mr. Sanderson was appointed secretary of Wellman, Seaver & Head, Limited, an office which he held until 1916. He was appointed a director of the company in 1914, and in 1917 became joint managing director. Later, when this company was merged into the Wellman Smith Owen Engineering Corporation, Limited, he became a director and commercial manager. For many years he had handled the Continental business of the Wellman companies, and he was a director of the Société Anonyme Wellman Smith Owen (France). His interests also extended to the United States of America, from whence he returned quite recently, having spent two years in Cleveland actively engaged as vice-president of the Wellman-Seaver-Morgan Company. By reason of his attractive personality, his business and other activities, Mr. Sanderson drew around himself a wide circle of friends. His death at the early age of 47 is greatly to be deplored.

REITH STEEL BUILDINGS, LIMITED, are being wound up voluntarily. Mr. H. Beswick, 9, John Street, Adelphi, London, is the liquidator.

Company News.

Howard & Bullough, Limited.—Quarterly dividend of 6d. per share, less tax.

Bull's Metal and Melloid Company, Limited.—Dividend of 5 per cent. for year, less tax.

Dalmellington Iron Company, Limited.—Interim dividend of 6d. per share, tax free, on the ordinary shares.

Gloucester Railway Carriage and Wagon Company, Limited.—Dividend for half-year at the rate of 5 per cent. per annum, less tax.

Iron Industries, Limited.—Capital £650,000 in £1 shares. Solicitors: Ashurst, Morris, Crisp & Company, 17, Throgmorton Avenue, London, E.C.

Grovesend Steel and Tinplate Company, Limited.—The dividends on the 6½ per cent. cumulative preference shares will in future be paid on October 1 and April 1 of each year, instead of September 1 and March 1.

Westinghouse Brake and Saxby Signal Company, Limited.—The annual meeting was held in London last week. LORD SOUTHBOROUGH, who presided, said that sales for the year showed a substantial increase. Like other industries, they were subject to the keenest competition, and such good fortune as they had enjoyed sprang from the policy of continually analysing methods of production for the purpose of adopting new and more scientific methods. This policy involved the continual purchase of the newest plant and machinery and the watching of experimental development.

Iron and Steel Output in December.

The National Federation of Iron and Steel Manufacturers report that the number of furnaces in blast at the end of December was 132, a net decrease of three since the beginning of the month, five furnaces having been blown in and eight having ceased operations during the month. The production of pig-iron in December amounted to 540,400 tons, compared with 544,400 in November, and 559,100 tons in December, 1927. Last month's production included 170,300 tons of hematite, 219,600 tons of basic, 114,200 tons of foundry and 14,500 tons of forge iron. Production of steel ingots and castings in December amounted to 683,100 tons, compared with 762,500 in November, and 604,900 tons in December, 1927.

The December production brings the total production for the year up to 6,611,300 tons of pig-iron and 8,525,100 tons of steel ingots and castings, compared with 7,292,900 tons and 9,097,100 tons respectively in 1927.

Students' Corner.

Q.—What is the necessary composition of the sand suitable for the steel, iron, and brass foundries?

A.—(1) Siliceous for resisting the heat of the molten metal; (2) Clayey for bonding the particles of sand together; and (3) Dampness for giving plasticity to the sand.

Q.—What are the desirable constituents for facing sands, core sands, and loam mixtures?

A.—Silica; clay; water; opening material; coal dust; gums and blackings, because Silica means refractoriness; clay and gums induce bond, id est—cohesiveness; water makes for plasticity; the opening material creates porosity, whilst coal dust and blackings are present for preventing the fusing together of the weak silicates in the sand, thus ensuring clean stripping and a clean skin on the castings.

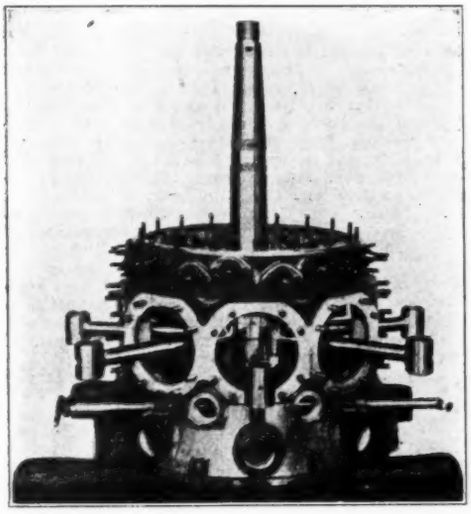
Q.—What does the opening material consist of?

A.—Horse manure; fine sawdust; chopped straw; peat; fibrous moss-litter, etc.

THE EMPLOYEES' CHILDREN of Messrs. Rolls Royce, at Derby, were recently entertained at a party, and the committee, under the chairmanship of Mr. A. Wormald, who had charge of the arrangements, was accorded a vote of thanks for their kindness.

F.T.J. 25.1.29

On long lone flights



The Wright engine with which Col. Lindbergh crossed the Atlantic. The castings were of British Aluminium.

The Avro "Avian" light aeroplane with which Squadron Leader Bert Hinckler flew to Australia in 15½ days. The A.D.C. Cirrus engine had aluminium alloy castings.

Aluminium Alloys *stood the test*

THE BRITISH ALUMINIUM CO., LTD., Aluminium Producers, ADELAIDE HOUSE, LONDON, E.C.4

WARNER'S CYLINDER PIG IRON

THE WORLD'S BEST

BRAND "WARNER C.B.R."

As supplied to the leading....
RAILWAY COMPANIES, LOCOMOTIVE, DIESEL and OIL ENGINE BUILDERS.
Also unequalled for
AUTOMOBILE CYLINDER BLOCKS, COMPRESSORS, ENGINEERS' TOUGH CASTINGS and CHILLED ROLLS.

WARNER & CO. LTD.

CARGO FLEET,
MIDDLESBROUGH ON TEES.

TELEGRAMS:
REFINERY MIDDLESBROUGH.

ALSO MAKERS OF
HIGH CLASS REFINED PIG IRON
IN SMALL PIGS, FOR ALL KINDS OF
MALLEABLE CASTINGS

TELEPHONE:
MIDDLESBROUGH 4265.

Iron and Steel Markets.

Pig-Iron.

MIDDLESBROUGH. — Resulting from increased activity in home demands, as previously noted, makers of Cleveland iron now find it difficult to meet current requirements, stocks having diminished to such an extent that furnace outputs must eventually be enlarged to cope with contracts already booked on forward account. Primarily, the shortage is due to the heavy increase in the consumption of pig-iron in the local steel furnaces. All the principal pig-iron producers are steel manufacturers also, and, of course, they place their own needs first. In other directions home industrial requirements tend to expand, and there is certainly a better export inquiry, although overseas shipments are still limited owing to the high cost of Cleveland iron in comparison with Continental qualities. Meantime, ironmasters continue firm in their policy of maintaining prices at the present levels, as indicated in current quotations, which remain as follow:—No. 1 Cleveland foundry iron, 68s. 6d. per ton; No. 3 G.M.B., 66s.; No. 4 foundry, 65s.; No. 4 forge iron, 64s. 6d. per ton.

Similar conditions to those above outlined prevail in the Tees-side hematite market, production now being hardly equal to the needs of the trade. Makers are, however, still prepared to negotiate home sales on the basis of 71s. per ton for East Coast mixed numbers, with No. 1 quality 6d. per ton extra. On the North-West Coast prices are at the same level, Bessemer mixed numbers making 71s. per ton at works.

LANCASHIRE.—In the local markets for foundry pig, although temporarily quiet, a more confident view of the position is entertained, and a few substantial orders have been recently booked on forward account. So far no change in prices has been reported, quotations remaining firm, with Derbyshire No. 3 at 68s. to 68s. 6d., Staffordshire 67s. 6d. to 68s., and Scotch brands from 87s. 6d. to 90s., according to brand, all delivered Manchester or equal.

THE MIDLANDS.—An improving tendency may also be noted in the demand for foundry pig in the Black Country area, some of the Derbyshire furnaces having done substantial business recently for forward delivery, for which 60s. is now a general price, with Northants. No. 3 quoted at about 55s. and North Staffordshire quality at 60s. 6d. to 61s. f.o.t. works.

SCOTLAND.—No fresh developments are reported in connection with the Scottish markets for foundry pig, and the makers are disappointed at the small amount of business which is coming forward. The labour troubles among the light castings founders and malleable workers still continue, and this, of course, is having a retarding effect on the market. The general quotation for No. 3 Scotch foundry is still 70s.

Finished Iron.

At Birmingham this week prices for the various grades of iron are quite unchanged, but in certain directions it is reported that the demand for crown iron is a little better. Business, however, is very patchy, and there is nothing like a sufficient quantity being ordered to keep the mills regularly employed. Crown iron is quoted at from £9 to £9 5s. from works in this district, and also Lancashire and Derbyshire, while nut and bolt iron, for which the demand is very poor indeed owing to continued Continental competition, is quoted at £8 12s. 6d. to £8 17s. 6d. delivered in this area. Staffordshire marked bars are still quoted at £12 at makers' works, which figure has been operative since April last. Makers are fairly well engaged and are sanguine of further developments.

Scrap.

Markets for most descriptions of foundry cast scrap metals continue inactive. On the North-East Coast this week there has been a little better demand for ordinary sorts at 61s. per ton delivered, an advance of 1s. per ton on last week's price, while machinery qualities are quoted at 65s. per ton. In the Midlands there is a good demand for cast-iron scrap, and for machinery quality, broken into cupola sizes, 65s. delivered is offered, with 55s. delivered for light cast-iron scrap. In Scotland there is not much improvement in the position of machinery cast-iron scrap at 65s. to 66s., and for heavy ordinary material, to the same specification, 61s. 3d. is quoted. Old cast-iron railway chairs are at 65s. Light cast-iron scrap is quoted at 58s. The above prices are all per ton delivered f.o.t. consumers' works.

Steel.

The improvement recently observable in the steel market has been well maintained, and a considerable volume of business has been reported for export to the Far East and other foreign destinations. Prices of Continental semis are very firm and are inclined to increase, which still further improves the position of British makers of this class of steel. Furthermore, only small quantities of Continental material are being offered in the British markets, and even for these extended times of delivery are required. The tinplate market remains quiet, and business is rather slow. The works have a fair number of orders on their books, but they are still experiencing difficulty with regard to obtaining specifications and delivery instructions.

Metals.

Copper.—Although closing last week a few shillings below the level previously reached, the position in warrant copper markets may be regarded as distinctly firm and steady. The standard market, although not very active, has had an easier tone, and as far as the London market is concerned stocks are very closely held and most of the business seems to have been in the nature of bear covering. With regard to the outlook for the future, it is confidently anticipated that a further increase in consumptive demand will be forthcoming.

Closing quotations are :—

Cash.—Thursday, £74 16s. 3d. to £74 17s. 6d.; Friday, £75 1s. 3d. to £75 2s. 6d.; Monday, £75 7s. 6d. to £75 8s. 9d.; Tuesday, £75 13s. 9d. to £75 15s.; Wednesday, £76 1s. 3d. to £76 2s. 6d.

Three Months.—Thursday, £72 18s. 9d. to £73; Friday, £73 7s. 6d. to £73 8s. 9d.; Monday, £73 13s. 9d. to £73 15s.; Tuesday, £73 17s. 6d. to £73 18s. 9d.; Wednesday, £74 5s. to £74 6s. 3d.

Tin.—The outlook for standard tin, though still somewhat indefinite, is regarded as fairly favourable, on the whole, an opinion supported by increased buying from the East in the American market, and prospects of increased world consumption in the near future. In this connection Messrs. Henry Gardner & Company, Limited, in their weekly report, state that at the present moment the metal's only salvation appears to be in the "group." Should their support not be forthcoming, values will go lower.

Official closing prices :—

Cash.—Thursday, £223 to £223 2s. 6d.; Friday, £224 2s. 6d. to £224 5s.; Monday, £222 to £222 5s.; Tuesday, £223 to £223 5s.; Wednesday, £223 to £223 2s. 6d.

Three Months.—Thursday, £222 7s. 6d. to £222 10s.; Friday, £223 5s. to £223 7s. 6d.; Monday, £221 10s. to £221 15s.; Tuesday, £222 7s. 6d. to £222 10s.; Wednesday, £222 7s. 6d. to £222 10s.

Spelter.—The tone of the week's markets for ordinary spelter continues uncertain, although consumptive demand has been on a fair scale, and it would appear that users are not particularly well covered, since some inquiry has been experienced for forward delivery. On the whole, all indications point to values remaining steady at the present level.

Daily quotations are :—

Ordinary.—Thursday, £26 1s. 3d.; Friday, £26 3s. 9d.; Monday, £26 1s. 3d.; Tuesday, £25 17s. 6d.; Wednesday, £25 15s.

Lead.—The market for foreign pig continues featureless, and demand has been very limited, with the exception of a small inquiry from the Continent. The general position does not seem to have disclosed much change, and until there is a revival in demand there is no prospect of anything but continued steady markets.

Prices have been :—

Soft Foreign Prompt.—Thursday, £22 2s. 6d.; Friday, £22; Monday, £22 5s.; Tuesday, £22 3s. 9d.; Wednesday, £22 1s. 3d.

European Steel Syndicates.

The negotiations for the renewal of international syndicates began at the Paris meeting in December of the Continental Steel Trust and the Erma (European Rail Makers' Association). In the case of the latter, whose agreement will nominally expire on June 30, 1929, a special committee was appointed to consider the question of renewal and other matters, but this committee has not yet met.

No special committee is foreseen for the discussion of the continuance of the Continental Steel Trust, and as no special sitting has been convened, the ordinary meeting in March will decide as to whether notice should be given on April 1, to become effective on October 31, 1929. At the Paris meeting, on behalf of the German group, expression was given of their complete lack of interest in the Trust in its present form, and a demand was made for meeting the German complaints regarding their inadequate quota and excessive penalties. Moreover, it was urged that the continuance of the Trust must be made dependent on the creation within a conceivable period of selling syndicates for semi-finished material, shapes, bars, etc.

According to the feeling prevailing in Westphalia at the moment—an Essen correspondent states—it is probable that the Germans will give notice to determine the agreement in order to force their wishes in connection with the renewal of the Trust. Contrary to the Germans, the Western steel producers are interested in the present structure of the Trust, and the concessions made by the latter to the Germans in Paris are regarded as insufficient.

The same Essen correspondent also states that the prospects of the renewal of the Rail Association are at present considered not to be very promising. In this case there is a united front of the German, Belgian, French and Luxemburg works with relation to the British group, who are maintaining their special claims to retain their markets in the British Dominions. Then trouble is brewing, also, due to the unsettled dispute concerning the refusal of the British group to pay penalties for deliveries exceeding their quota.

Neither the Rail Association nor the International Tube Syndicate is directly affected by the new development in the Continental Steel Trust. It is expected that the Tube Syndicate would remain in existence even if the Steel Trust were dissolved. On the other hand, the reserve shown by wire-rod makers seems to be due to the uncertainty concerning the continuation of the Steel Trust. The International Wire Rod Syndicate has provisionally been extended to June 30, 1929.

International Standardisation of Methods for Testing Cast Iron.

At a meeting of the Council of the Institute of British Foundrymen, held at Birmingham last Saturday, the following resolution was carried unanimously :—

(1) That the Secretary be requested to get in touch with Mr. Ronceray (hon. secretary) and ask for a meeting of the International Test Bar Committee to be called to take place in London during June—the Convention Week.

(2) That each national association be asked to send one delegate for a membership up to 500, and a further delegate for each complete 500 members over the first 500.

(3) That after very thorough investigation of the methods mentioned at the last meeting, they are of opinion that the B.E.S.A. Specification No. would form a suitable basis for discussion for adoption as an international specification for grey cast iron.

Publication Received.

The Mechanical World Year-Book. (Price 1s. 6d., published by Emmott and Company, Limited, 65, King Street, Manchester.

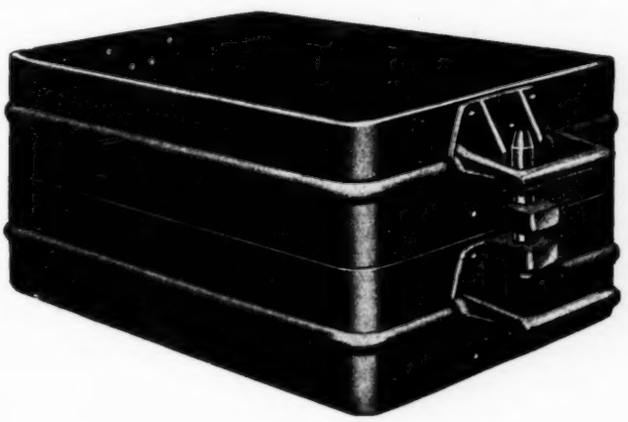
In the 1929 edition of this comprehensive handbook several new sections have again been introduced, and of these one deals with the proportions of flywheels. Several tables on steel tubes, valve-rod ends, comparative stresses and the economical life of plant and machinery have been included, and should prove of value to foundrymen. Undoubtedly the foundryman needs a reference handbook just as much as the engineer, and this year-book certainly provides a quantity of information of the type required in the modern foundry.

HIGHER PRODUCTION AT LESS COST AND MORE ACCURATE CASTINGS WITH

Sterling BOXES

LESS FETTLING
FEWER WASTERS
CLEANER CASTINGS

YOUR FOUNDRY IS WORKING AT A DISADVANTAGE WITHOUT THEM.



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STERLING FOUNDRY SPECIALTIES LTD.

London Office:
13, VICTORIA STREET, S.W.1.

BEDFORD

Telephone: 3345 BEDFORD.
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Code: WESTERN UNION.

WEEKLY PRICE CURRENT.

COPPER.

	£ s. d.
Standard cash	76 1 3
Three months	74 5 0
Electrolytic	79 10 0
Tough	76 10 0
Best selected	77 0 0
Sheets	102 0 0
India	86 15 0
Wire bars	78 12 6
Do. January	78 12 6
Do. February	78 12 6
Ingot bars	78 12 6
H.C. Wire rods	82 15 0
Off. av. cash, December	69 7 7 7/32
Do. 3 mths., December	69 4 4 1/2
Do., Sttlmnt., December	69 7 7 1/32
Do., Electro, December	75 4 10 25/32
Do., B.S., December	73 16 10 1/2
Aver. spot price, copper, Dec.	69 7 7 7/32
Do. Wire bars, December	75 9 8 15/32
Solid drawn tubes	14 1/4d.
Brazed tubes	14 1/4d.
Wire	10 1/4d.

BRASS.

Solid drawn tubes	12 1/4d.
Brazed tubes	14 1/4d.
Rods, drawn	11 3/8d.
Rods, extd. or rlld.	7 1/2d.
Sheets to 10 w.g.	10 7/8d.
Wire	10 3/8d.
Rolled metal	10 3/8d
Yellow metal rods	7 1/2d.
Do. 4 × 4 Squares	8d.
Do. 4 × 3 Sheets	8 1/2d.

TIN.

	£ s. d.
Standard cash	223 0 0
Three months	222 7 6
English	222 15 0
Bars	224 15 0
Straits	225 0 0
Australian	224 0 0
Eastern	224 15 0
Banca	223 15 0
Off. av. cash, December	227 13 11 7/10
Do., 3 mths., December	226 8 3 9/10
Do., Sttlmt., December	227 12 10 1/2
Aver. spot, December	227 13 11 7/10

SPELTER.

	£ s. d.
Ordinary	25 15 0
Remelted	24 10 0
Hard	20 0 0
Electro 99.9	28 10 0
English	26 5 0
India	21 10 0
Zinc dust (Nom.)	36 10 0
Zinc ashes	8 5 0
Off. aver., December	26 12 2 1/2
Aver., spot, December	26 12 2 1/2

LEAD.

	£ s. d.
Soft foreign ppt.	22 1 3
English	23 10 0
Off. average, December	21 10 8 1/2
Average spot, December	21 6 10 7/10

ZINC SHEETS, &c.

	£ s. d.
Zinc sheets, English	34 0 0
Do. V.M. ex whf.	33 10 0
Rods	44 0 0
Boiler plates	32 0 0
Battery plates	33 0 0

ANTIMONY.

	£ s. d.
Special brands, Eng.	54 10 0
Chinese	37 15 0
Crude	33 10 0

QUICKSILVER.

	£ s. d.
Quicksilver	22 5 9

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—	
25%	£7 17 6
45/50%	£12 0 0
75%	£19 0 0
Ferro-vanadium—	
35/50%	14/- lb. Va.
Ferro-molybdenum—	
70/75% c. free	4/- lb. Mo.
Ferro-titanium—	
23/25% carbonless	1/- lb.
Ferro-phosphorus, 20/25%	£18 0 0
Ferro-tungsten—	
80/85%, c. fr.	1/5 lb.
Tungsten metal powder—	
98/99%	1/10 lb.
Ferro-chrome—	
2/4% car.	£30 15 0
4/6% car.	£21 15 0
6/8% car.	£20 17 6
8/10% car.	£20 10 0
Ferro-chrome—	
Max. 2% car.	£33 5 0
Max. 1% car.	£37 2 6
Max. 0.70% car.	£44 0 0
70% carbonless	1/- lb.
Nickel—99% cubes or pellets	£175 0 0
Ferro-cobalt	9/- lb.
Aluminium 98 99%	£95 0 0
Metallic chromium—	
96.98%	2/6 lb.
Ferro-manganese (net)—	
76/80% loose	£13 15 0
76/80% packed	£14 15 0
76/80% export	£14 10 0
Metallic manganese—	
94/96% carbonless	1/6 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	£0 2 3
Finished bars, 18% tungsten	£0 ? 9

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 1/16 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ¼ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

Scrap from high-speed tool steel—	
Scrap pieces	3d.
Turnings and swarf	1d.

Per lb. net, d/d steel makers' works.

SCRAP.

	£ s. d.	£ s. d.
South Wales—		
Hvy. steel		3 10 0
Bundled steel and shrngs.	3 5 0	to 3 9 0
Mixed iron and steel	3 4 0	to 3 5 0
Heavy cast iron	2 17 0	to 2 18 0
Good machinery for foundries	2 17 6	to 3 0 0
Cleveland—		
Heavy steel		3 1 6
Steel turnings		2 8 6
Cast iron borings		2 4 0
Heavy forge		3 7 6
W.I. piling scrap		3 0 0
Cast-iron scrap	3 1 0	to 3 5 0
Lancashire—		
Cast-iron scrap	2 15 0	to 3 5 0
Hvy. wrought		3 10 0
Steel turnings		2 5 0

London—Merchants' buying prices delivered yard.

	£ s. d.
Copper (clean)	57 0 0
Brass	39 0 0
Lead (less usual draft)	19 10 0
Tea lead	16 10 0
Zinc	17 0 0
New aluminium cuttings	67 0 0
Braziery copper	52 0 0
Gunmetal	50 0 0
Hollow pewter	150 0 0
Shaped black pewter	105 0 0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast—	
Foundry No. 1	68/6
Foundry No. 3	66/-
Foundry No. 4	65/-
Forge No. 4	64/6
Hematite No. 1	71/6
Hematite M/Nos.	71/-
N.W. Coast—	
Hem. M/Nos. d/d Glas.	78/-
,, d/d Birm.	85/6
Midlands—	
Staffs. common*	67/6
,, No. 4 forge	56/-
,, No. 3 fdry.	60/6
Shrops. basic	—
,, Cold blast, ord.*	—
,, ,, roll iron*	—
* d/d Birmingham.	
Northants forge	52/-
,, fdry. No. 3	55/-
Derbyshire forge	59/-
,, fdry. No. 3	60/-
,, basic	65/-
Scotland—	
Foundry No. 1	75/-
,, No. 3	70/-
Hem. M/Nos.	75/-
Sheffield (d/d district)—	
Derby forge	61/6
,, fdry. No. 3	64/-
Lincs. forge	62/6
,, fdry. No. 3	65/6
E.C. hematite	81/-
W.C. hematite	82/6
Lincs. (at furnaces)—	
Forge No. 4	58/-
Foundry No. 3	61/-
Basic	60/-
Lancashire (d/d eq. Man.)—	
Derby forge	—
,, fdry. No. 3	68/-
Northants foundry No. 3	—
Dalzell, No. 3(special)	100/- to 102/6
Summerlee, No. 3	87/6 to 90/-
Glengarnock, No. 3	87/6 to 90/-
Gartsherrie, No. 3	87/6 to 90/-
Monkland, No. 3	87/6 to 90/-
Shotts, No. 3	87/6 to 90/-

FINISHED IRON AND STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£ s. d.	£ s. d.
Bars (cr.) nom.		10 5 0
Nut and bolt iron	8 12 6	to 8 17 6
Hoops		11 10 0
Marked bars (Staffs.) f.o.t.		12 0 0
Gas strip		11 10 0
Bolts and nuts, ¾ in. × 4 in.		15 5 0
Steel—		
Ship plates	8 7 6	to 8 12 6
Boiler plts.		10 10 0
Chequer plts.		10 12 6
Angles		7 17 6
Tees		8 17 6
Joists		7 17 6
Rounds and squares, 3 in. to 5½ in.		8 17 6
Rounds under 3 in. to ¾ in. (Untested)		7 15 0 and upwards
Flats, over 5 in. wide and up		8 7 6
Flats, 5 in. to 1½ in.		7 17 6
Rails, heavy		8 10 0
Fishplates		12 10 0
Hoops (Staffs.)		10 10 0
Black sheets, 24g.	10 0 0	to 10 10 0
Galv.cor.shts.,24g.	13 7 6	to 13 15 0
Galv. fencing wire 8g. plain		12 10 0
Billets, soft	6 5 0	to 6 12 6
Billets, hard	7 5 0	to 7 12 6
Sheet bars		6 0 0
Tin bars		6 0 0

PHOSPHOR BRONZE.

	Per lb. basis
Strip	1 3
Sheet to 10 w.g.	1 3½
Wire	1 4½
Rods	1 3½
Tubes	1 8
Castings	1 2½

Delivery 3 cwt. free.
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	per lb
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/3½ to 1/9½
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4½ to 1/10½
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks	9d. to 1/5½
Ingots rolled to spoon size	1/- to 1/8½
Wire round—	
3/0 to 10 G.	1/6½ to 2/1½

with extras according to gauge.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2X foundry, Phila.	21.26
No. 2 foundry, Valley	18.00
No. 2 foundry, Birm.	16.50
Basic	19.26
Bessemer	20.79
Malleable	20.01
Grey forge	19.26
Ferro-mang. 80% d/d	105.00
O.-h. rails, h'y at mill	43.00
Bess billets	33.00
O.-h. billets	33.00
O.-h. sheet bars	34.00
Wire rods	42.00
	Cents.
Iron bars, Phila.	2.12
Steel bars	1.95
Tank plates	1.90
Beams, etc.	1.90
Skelp, grooved steel	1.90
Skelp, sheared steel	1.90
Steel hoops	2.20
Sheets, black, No. 24	2.85
Sheets, galv., No. 24	3.60
Sheets, blue an'l'd, 9 and 10	2.10
Wire nails	2.65
Plain wire	2.50
Barbed wire, galv.	3.30
Tinplates, 100 lb. box	$5.35

COKE (at ovens)

Welsh foundry	25/- to 30/-
,, furnace	19/- to 23/-
Durham and North.	
,, foundry	18/-
,, furnace	15/3
Midlands, foundry	—
,, ,, furnace	14/-

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes	20 × 14	box	18/-
,,	28 × 20	,,	36/-
,,	20 × 10	,,	26/3
,,	18¾ × 14	,,	18/9
C.W.	20 × 14	,,	15/-
,,	28 × 20	,,	33/6
,,	20 × 10	,,	21/3
,,	18¾ × 14	,,	15/-
Terneplates	28 × 20		33/6 per box basis f.o.b.

SWEDISH CHARCOAL IRON & STEEL.

Pig-iron	£6 0 0 to £7 10 0
Bars, hammered, basis	£17 10 0 to £18 10 0
Bars & nailrods, rolled, basis	£15 15 0 to £16 15 0
Blooms	£10 0 0 to £12 0 0
Keg steel	£32 0 0 to £33 0 0
Faggot steel	£20 0 0 to £24 0 0
Bars & rods, dead soft, steel	£10 0 0 to £14 0 0

All per English ton, f.o.b. Gothenburg.

TUBES AND FITTINGS.

Up to and incl. 6 in.

	Tubes.	Fittings.
Gas	67½%	50%
Water	63½%	45%
Steam	60%	40%

W.I. 10% extra.

DAILY FLUCTUATIONS.

Standard Copper (cash).

		£	s.	d.	
Jan. 17 ..		74	16	3	inc. 3/9
,, 18 ..		75	1	3	,, 5/–
,, 21 ..		75	7	6	,, 6/3
,, 22 ..		75	13	9	,, 6/3
,, 23 ..		76	1	3	,, 7/6

Electrolytic Copper.

		£	s.	d.	
Jan. 17 ..		78	5	0	No change
,, 18 ..		78	5	0	,, ,,
,, 21 ..		78	5	0	,, ,,
,, 22 ..		78	5	0	,, ,,
,, 23 ..		79	10	0	inc. 25/–

Standard Tin (cash).

		£	s.	d.	
Jan. 17 ..		223	0	0	No change
,, 18 ..		224	2	6	inc. 22/6
,, 21 ..		222	0	0	dec. 42/6
,, 22 ..		223	0	0	inc. 20/–
,, 23 ..		223	0	0	No change

Tin (English ingots).

		£	s	d.	
Jan. 17 ..		223	0	0	No change
,, 18 ..		223	15	0	inc. 15/–
,, 21 ..		222	0	0	dec. 35/–
,, 22 ..		222	15	0	inc. 15/–
,, 23 ..		222	15	0	No change

Zinc Sheets (English).

		£	s.	d.	
Jan. 17 ..		34	5	0	No change
,, 18 ..		34	5	0	,, ,,
,, 21 ..		34	5	0	,, ,,
,, 22 ..		34	0	0	dec. 5/–
,, 23 ..		34	0	0	No change

Spelter (ordinary)

		£	s.	d.	
Jan. 17 ..		26	1	3	inc. 1/3
,, 18 ..		26	3	9	,, 2/6
,, 21 ..		26	1	3	dec. 2/6
,, 22 ..		25	17	6	,, 3/9
,, 23 ..		25	15	0	dec. 2/6

Lead (English).

		£	s.	d	
Jan. 17 ..		23	10	0	inc. 5/–
,, 18 ..		23	5	0	dec. 5/–
,, 21 ..		23	10	0	inc. 5/–
,, 22 ..		23	10	0	No change
,, 23 ..		23	10	0	,, ,,

AVERAGE MONTHLY PRICES OF STEEL SHIP ANGLES (NORTH OF ENGLAND).

Year.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1896	4 15 0	4 17 6	5 0 0	5 0 0	5 0 0	4 17 6	4 17 6	4 17 6	4 17 6	5 0 0	5 7 6	5 7 6	4 19 9½
1897	5 7 6	5 7 6	5 7 6	5 5 0	5 0 0	5 0 0	5 2 6	5 2 6	5 2 6	5 2 6	5 0 0	5 5 0	5 3 5½
1898	5 5 0	5 5 0	5 5 0	5 7 6	5 13 9	5 15 0	5 15 0	5 15 0	5 17 6	6 0 0	6 5 0	6 7 6	5 14 3
1899	6 10 0	6 12 6	6 15 0	6 15 0	6 17 6	6 17 6	7 0 0	7 0 0	7 5 0	7 5 0	7 12 6	7 15 0	7 0 5
1900	7 15 0	8 0 0	8 2 6	8 5 0	8 5 0	8 7 6	8 7 6	8 2 6	8 2 6	8 0 0	7 10 0	7 10 0	8 0 7½
1901	6 15 0	6 12 6	6 5 0	6 0 0	6 0 0	5 10 0	5 15 0	5 17 6	6 0 0	5 17 6	5 17 6	5 15 0	6 0 5
1902	5 12 6	5 10 0	5 10 0	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 7 6	5 11 8
1903	5 6 3	5 6 3	5 7 6	5 12 6	5 12 6	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 0 0	5 8 9
1904	5 0 0	4 17 6	5 2 6	5 5 0	5 5 0	5 5 0	5 5 0	5 5 0	5 0 0	5 0 0	5 0 0	5 5 0	5 2 6
1905	5 5 0	5 7 6	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 12 6	6 2 6	6 12 6	6 12 6	5 14 4½
1906	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	7 2 6	6 13 4
1907	6 17 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	6 12 6	6 12 6	7 0 5
1908	6 2 6	6 2 6	6 2 6	5 17 6	5 17 6	5 17 6	5 17 6	5 12 6	5 12 6	5 12 6	12 6	5 12 6	5 16 3
1909	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 7 6	5 7 6	5 7 6	5 7 6	5 7 6	5 7 6	5 7 6	5 9 7
1910	5 16 3	5 17 6	5 17 6	6 1 6	6 2 6	6 2 6	6 2 6	6 2 6	6 2 6	6 7 6	6 7 6	6 7 6	6 2 3½
1911	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 9 0	6 7 8½
1912	6 16 3	6 17 6	6 17 6	7 5 0	7 7 6	7 7 6	7 7 6	7 12 6	7 12 6	7 7 6	7 14 6	7 17 6	7 7 4½
1913	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 11 6	7 7 6	6 15 6	6 7 6	6 2 6	6 8 11½
1914	6 2 6	6 2 6	6 2 6	6 2 6	6 2 6	5 15 0	5 15 0	6 15 0	7 0 0	7 0 0	7 1 3	7 5 0	6 8 7½
1915	7 17 0	8 5 0	8 17 6	9 5 0	9 5 0	9 15 0	9 15 0	9 15 0	9 15 0	9 15 0	10 15 0	10 15 0	9 8 3½
1916	11 3 1½	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6
1917	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6
1918	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 17 6	18 5 0	16 1 9
1919	11 2 6	13 12 6	13 12 6	13 12 6	17 2 6	17 1 3	17 0 0	17 15 0	17 15 0	17 15 0	17 17 6	24 0 0	22 19 2
1920	19 10 0	20 0 0	21 10 0	22 0 0	23 5 0	24 0 0	24 0 0	24 0 0	24 15 0	24 10 0	24 0 0	24 0 0	15 11 7
1921	22 10 0	20 12 6	19 0 0	17 10 0	17 10 0	16 6 0	14 10 0	14 3 4	13 10 0	11 15 0	10 0 0	10 0 0	9 8 3½
1922	9 17 6	10 0 0	10 0 0	10 0 0	10 0 0	9 17 6	9 10 0	8 15 7½	8 14 0	8 12 6	8 12 6	8 12 6	9 7 8½
1923	8 18 1½	9 1 3	9 14 0	10 0 0	10 0 0	10 0 0	9 8 9	9 9 6	9 10 0	9 8 9	9 11 6	9 18 9	9 11 8½
1924	10 0 0	9 18 1½	9 17 6	9 17 6	9 17 2	9 11 3	9 15 0	9 15 0	9 9 4½	9 6 6	9 5 0	9 5 0	9 13 1½
1925	9 2 9	9 0 11½	9 0 0	8 15 9	8 10 3½	8 9 0½	8 6 3	8 2 6	7 19 0½	7 12 3	7 5 0	7 2 6	8 5 5½
1926	7 2 6	7 2 6	7 2 6	7 3 4	7 2 6	7 3 9	7 7 6	7 8 5½	7 9 0	7 12 6	7 16 3	8 0 6	7 7 7½
1927	7 18 9	7 17 6	7 17 6	7 14 8½	7 13 9	7 12 6	7 12 6	7 12 6	7 12 6	7 12 6	7 12 6	7 12 6	7 14 1½
1928	7 12 6	7 14 9	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 16 10½

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